Technological Solutions for the Monitoring and Enforcement of Urban Logistics Activities: Av. Guerra Junqueiro case study

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Soluções tecnológicas para monitorização e fiscalização da logística urbana: caso de estudo da Avenida Guerra Junqueiro

Resumo

Um dos problemas comuns a todas as cidades é o trânsito. E os problemas de trânsito podem ser causados por diferentes situações, contudo esta dissertação centra-se na problemática da grande densidade de veículos de mercadorias dentro do centro das cidades, o que muitas vezes resulta em problemas quando estes fazem cargas ou descargas. Se conseguirmos monitorizar e regular estas actividades de cargas e descargas, os problemas podem ser mitigados originando melhorias no trânsito e menos conflitos com outros utilizadores do espaço público.

Este trabalho teve como objectivo estudar o processo de monitorização e fiscalização das operações de cargas e descargas efectuadas em contexto urbano, e o caso-estudo foi na Avenida Guerra Junqueiro em Lisboa. Estudou-se a implementação de duas tecnologias diferentes para monitorizar estas operações. Uma solução consistia em utilizar parquímetros que geram autorizações de estacionamento com a validade de 30 minutos após a apresentação de um cartão; e a outra solução foi a implementação de sensores no chão dos lugares de estacionamento das baías de cargas e descargas que monitorizam a entrada e saída de veículos.

Foi analisado o desempenho destas duas tecnologias, baseado nos seus custos e benefícios, com o objectivo de se determinar qual a solução que melhor se adequa às necessidades da entidade responsável pela fiscalização do estacionamento em Lisboa, a EMEL. A metodologia utilizada para estudar os resultados do caso-estudo foi uma adaptação da Análise Custo-Benefício (ACB) sugerida pela Comissão Europeia. Esta adaptação teve de ser feita devido à pequena dimensão do caso-estudo e também porque não foi possível medir alguns impactos indirectos (ou não estavam disponíveis). Tanto antes como depois da implementação das tecnologias na Avenida Guerra Junqueiro, foram realizadas observações no local para se perceber a dinâmica e o número de operações de cargas e descargas que eram efectuadas na avenida. A avaliação segundo uma ACB foi efectuada para um horizonte temporal de 15 anos, calculando assim o Valor Actual Líquido (VAL) das duas alternativas no final desse período. Foi realizada uma previsão do que seria expectável se as tecnologias fossem implementadas em todas a baías de cargas e descargas em Lisboa.

As conclusões indicam que fixando o valor dos benefícios para a EMEL, é a alternativa com os parquímetros que gera um VAL mais elevado, mas a solução com os sensores tem a vantagem de ser capaz de monitorizar as operações de cargas e descargas de uma forma permanente e automática.

Palavras-chave: Análise Custo-Benefício; Cargas e Descargas; Estacionamento Urbano; Sistemas Inteligentes de Transporte; Transporte Urbano de Mercadorias.

Technological solutions for monitoring and enforcing city logistics: case study of Guerra Junqueiro Avenue

Abstract

One common problem of all cities is traffic. And traffic can be caused by many different situations, but the focus of this dissertation goes to the problematic of the high density of freight vehicles within the city center, that often result on problems while proceeding with loading or unloading activities. If we could monitor and regulate these delivery operations, these problems could be mitigated resulting in traffic improvements and less conflicts with other public space users.

The objective of this work was to study the process of monitoring and enforcing loading and unloading activities in urban context, and the case study was in Lisbon's Guerra Junqueiro Avenue. It was studied the implementation of two different technologies to monitor these activities, one alternative consisted in using adapted parking meters that issued a parking ticket for freight vehicles that expired after 30 minutes after using a contactless card, and the other alternative was the implementation of sensors on the ground of the parking places of the loading/unloading parking bays that could monitor the entrance and exit of vehicles.

It was analysed the performance of these two technologies, based on their costs and benefits, in order to determine which solution was better suited to attend the needs of the public company responsible for on-street parking in Lisbon, EMEL. To study the results given by the case study, it was used an adaptation of the methodology of Cost-Benefit Analysis (CBA) suggested by the European Commission. This adaptation was made due to the small dimension of the case study and because some indirect impacts could not be measured (or were not available). Two periods of observations on-site were conducted in order to give an overview of the situation in the avenue before and after the implementation of both technological solutions. The evaluation with the CBA method was performed with a time-horizon of 15 years, which gave the Net Present Value (NPV) of both alternatives at the end of that period. It was also predicted what to expect if the technologies would be implemented on all loading and unloading parking bays (LUPBs) in the city of Lisbon.

The conclusions of this work indicate that for the same amount of benefits for EMEL, the alternative with the adapted parking meters gives a higher NPV, but the alternative with the sensors has the advantage of being able to monitor the loading and unloading activities permanently and automatically.

Keywords: Cost-Benefit Analysis; Intelligent Transport Systems; Loading and Unloading Activities; Urban Freight; Urban Parking.

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LIST OF ABBREVIATIONS

APM – Adapted Parking Meter

CBA – Cost-Benefit Analysis

CEA – Cost-Effectiveness Analysis

CEDM – Centre for Eco-Friendly City Freight Distribution

CITYLOG – Sustainability and Efficiency of City Logistics

C-LIEGE – Clean Last Mile Transport and Logistics Management

CL – City Logistics

EMEL – Empresa Municipal de Estacionamento de Lisboa (Municipal Parking Company of Lisbon)

ERTICO – ERTICO is the network of Intelligent Transport Systems and Services stakeholders in Europe.

ITS – Intelligent Transport Systems

LUPB – Loading/Unloading Parking Bay

NPV – Net Present Value

MCA – Multi-Criteria Analysis

SMILE – Street Management Improvements for Loading/unloading Enforcement

OCC – Operation Control Center

START – Short Term Actions to Reorganize Transport of goods

STRAIGHTSOL – Strategies and measures for smarter urban freight solutions

TURBLOG_WW – Transferability of Urban Logistics Concepts and Practices from a World Wide Perspective

UFT – Urban Freight Transport

UGM – Urban Goods Movement

USA – United States of America

VDS – Vehicle Detection Sensor

1 INTRODUCTION AND OBJECTIVES

1.1 MOTIVATION

Large quantities of goods are needed to feed both domestic and commercial activities of urban areas, which lead to the need to transport goods. But without a good transport logistics the urban areas would be a chaotic place to live and work.

In this dissertation the focus goes to the first/last mile of a transport chain, particularly, the loading and unloading activities. This is an area that has not been much developed by municipalities and transport companies in the past, but due to its economic importance these entities begun to give it more importance.

In Lisbon, as in every urban centre, there are space limitations and if the activities of loading and unloading are not made on dedicated spaces, these limitations can be even more problematic. Since these activities are very important for urban areas, there is a need to monitor them and apply the necessary enforcement that will minimize its negative impacts. The enforcement is essential to ensure the adequate behaviour of the all the actors involved, however it is expensive, especially if it is based on parking officers. The recent developments in Intelligent Transport Systems (ITS) give the possibility to use technology to monitor and enforce these activities, which can reduce its costs, increase the detection rate and create a more automatic enforcement.

The municipal regulation of loading/unloading activities in the City of Lisbon is currently suspended *"until the technologic solutions that are behind it show a degree of suitability and effectiveness compatible with the goals that are pursued by the concerned regulatory"* (Rodrigues *et al.*, 2012, pg. 4), and the public entity responsible for on-street parking management (EMEL) is studying the implementation of technologies in the process of monitoring and enforcing these activities. Therefore there is a need to study which technology ensures an effective process of monitoring and enforcing of these activities, that doesn't encumber the City of Lisbon.

This dissertation will be focused on studying the application of technology on the monitoring and enforcement of the loading and unloading activities, with the purpose of reducing the costs and creating a more automatic enforcement.

1.2 OBJECTIVE

One of the many problems in cities nowadays is traffic. And traffic can be caused by (among others): a lack of urban planning, poor condition of transport infrastructures, or high density of freight vehicles within the city centre.

Since freight vehicles share the transport infrastructures with public transport vehicles as well as private vehicles (and also with pedestrians), this often results on problems in freight deliveries within the cities. So, if we could monitor and regulate these delivery operations, these problems could be mitigated resulting in traffic improvements and less conflicts with other public space users.

The focus of this dissertation is to study the process of monitoring operations of loading and unloading freight in urban context. It is an area that has not been explored much; nevertheless there are some innovative projects in several European cities, such as Barcelona, Bilbao and Treviso, among others.

In this dissertation the case study is in Lisbon and it consists on testing two different technologies to monitor the loading and unloading operations in an Avenue characterized by many different commercial activities. The two technologies consist in parking meters exclusively for freight vehicles, and sensors that monitor the entrance and exit of vehicles in the loading/unloading parking bays (LUPBs). The main objective was to help choosing the right technology for controlling and monitoring loading and unloading activities on the whole city, and to provide evidence and the grounds for developing the Municipal Regulation on loading and unloading operations.

The objective of this work is to analyse the performance of these two technologies, in order to determine which solution is better suited to attend the operational needs of EMEL. The analysis is made based on a list of costs and benefits of the implementation of both technologies, and then a methodology of Cost-Benefit Analysis is applied.

1.3 STRUCTURE

The first chapter (Chapter 2) explains the concept of City Logistics. It starts to give a definition of this concept, followed by an overview of the major problems and challenges that this area of urban transport has been facing in the recent past. Afterwards, the chapter continues by describing the main stakeholders, and providing a description of the research that has been done in Europe and the importance that the European Commission gives to City Logistics. After this chapter, in the Chapter 3, it is given a list of measures carried out by public and private sector to control and ease city logistics (a detailed list of the projects reviewed by the author is presented in the Annex 1).

In the Chapter 4 the focus goes to the process of evaluating ITS projects. The chapter starts by giving a definition of the concept of Intelligent Transport Systems (ITS), which are tools used in the transport area to improve the efficiency and mitigate other problems, making the transport operations easier. It continues by discussing the difference between the perspective of the private and the public sectors, and providing an overview of the most popular evaluation tools in this area. It finishes with a special focus of Cost-Benefit Analysis (CBA) because it is the most common in the transport area.

There are two chapters dedicated to the case study. The first, the Chapter 5, aims at giving the context on which it was implemented, giving an overview of the city of Lisbon and the company that was responsible for the implementation, EMEL. Then explains how it was implemented, what the objectives were and which stakeholders were involved on the project.

In the second chapter dedicated to the case study, the Chapter 6, it is presented the evaluation methodology that is used in this work to evaluate the results of the case study. The two technologies implemented are analysed using a simplified methodology of Cost-Benefit Analysis, because there were some data limitations, which are explained in the first part of this chapter.

To finish, the Chapter 7 presents the conclusions of this dissertation, and also the next steps that could be done in the area of City Logistics.

1.4 METHODOLOGY

This dissertation is divided in three parts.

The first one (**Chapter 2**) explains the concept of city logistics, followed by the **Chapter 3** that gives an overview of the main measures and technologies that are used by municipalities to mitigate the problems that are characteristic of this area of transport.

The second part (**Chapter 4**) is mainly focused on the evaluation of Intelligent Transport Systems (ITS) projects. It begins by explaining the concept of Intelligent Transport Systems (ITS), and then aims at explaining the importance of the process of evaluation for the decision-makers, and how this process is done nowadays. This chapter finishes with the description of the evaluation methodology of Cost-Benefit Analysis and discusses the main limitations of this method.

On the last part of this dissertation (**Chapter 5 and 6**), the author presents the case study in Lisbon and the technologies that were used, and then the author evaluates the two technologies of the case study in Lisbon. In this analysis it is used a simplified methodology of Cost-Benefit Analysis to compare the two technologies' performance. It is studied which one gives better results, taking into account the costs and benefits of each technology.

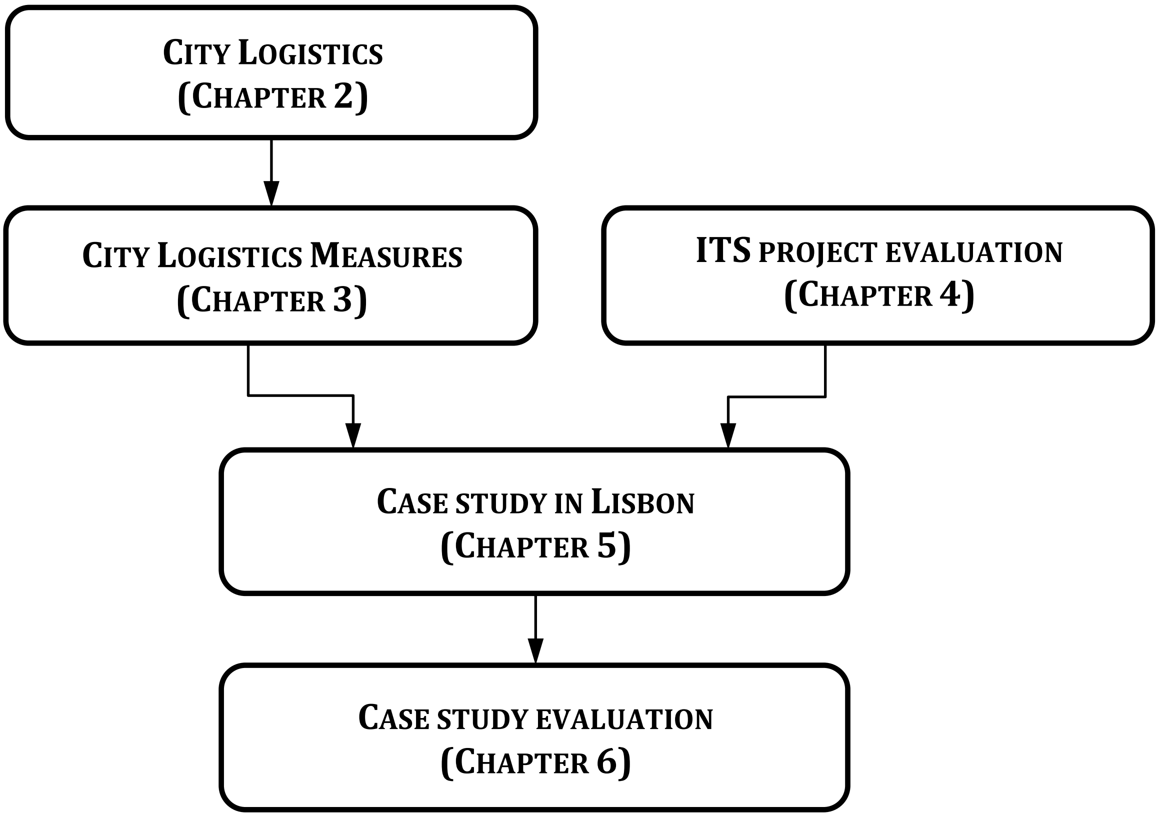


Figure 1.1 - Dissertation methodology

2 CITY LOGISTICS

2.1 DEFINING CITY LOGISTICS

Defining City Logistics (CL) is not an easy task, because there is not a unanimous consistent definition of the concept. In fact, there have been used many different terms to refer to the transport of urban supplies (e.g. “Urban Goods Movement” and “Urban Logistics”), which is an evidence of the various different interpretations of the concept. Therefore, the concept of city logistics has to be considered in the broadest sense of the term. There are many different authors’ opinions on what city logistics refers to, and to exemplify that varying scope of existing interpretations of this concept, some examples are given in this dissertation.

Barceló et al. (Barceló et al. 2005, pg. 326) states that “*freight transport in urban areas, specifically the freight flows associated to the supply of city centres with goods is usually referred to as ‘city logistics’* “. Taniguchi & Thompson (Taniguchi & Thompson 2002, pg. 45) see CL as “*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*”. Qiu et al. (Qiu, Yang, & Yang., 2005) have a wider understanding of CL, stating that the concept encompasses not only the movement and routing of freight on all transport modes, but also the associated activities of managing freight at each end of its journey. According to Crainic et al. (Crainic, Ricciardi, & Storchi, 2009) CL aims to optimize and reduce the nuisances of urban freight transport, by taking into account all movements of goods and all stakeholders of urban areas. To explain the concept of CL there are used other terms in scientific literature. Back in the 80’s McDermott (McDermott, 1980) stated that Urban Goods Movement (UGM) comprised all freight transport that occurred in an urban area of a city with a population of more than 50,000. Dablanc used the term “urban logistics” (Dablanc 2007, pg. 284) and defined it as “*as any service provision contributing to an optimized management of the movement of goods in cities*”.

More recently Stathopoulos *et al.* has stated that *“City logistics studies the problems relating to freight movement, such as congestion, time-window regulations, on street loading/unloading, parking and environmental emissions caused by freight vehicles”* (Stathopoulos *et al.*, 2012, pg. 34). This definition is congruent with the author’s understanding of CL and therefore applied in the present dissertation because it clearly describes the essence of the CL concept.

2.2 INCREASING SIGNIFICANCE

Despite the idea of dealing with urban freight issues is a relatively new concept, it is important to note that it is older than what most people think. During the times of the Roman Empire, the emperor Julius Caesar thought that it was needed to move freight deliveries to the off-hours so he promulgated an edict, in 45 BC, that banned commercial deliveries during daytime (Holguín-Veras, 2008). There is also evidence that, 70 years ago, some business organizations already used co-operative delivery actions, such as consolidation, to mitigate the negative externalities of urban goods movement

(Cadotte & Robicheaux, 1979). However the significance and complexity of CL has been, and still is, growing. The scientific literature indicates that the prime factors responsible for this increase of importance and complexity of logistics in urban areas are:

- **Dynamic inventory management:** service level is now considered as a value for the product – because factors such as lead time and attendance can be the difference between two services – and retailers adopt policies of continuous inventory replenishment – because they have less available space inside stores and want to reduce their inventories – which enhances *dynamic inventory management* (de Magalhães, 2010; Regan & Golob, 2005).
- **E-commerce:** this type of business has led to the increase of home deliveries and intensification of transporting freight through inner-city areas (Chwesiuk, Kijewska, & Iwan, 2010; Goldman & Gorham, 2006; Oliveira, Nunes, & Novaes, 2010).
- **Evolving environmental awareness:** city planning has been focused primarily on passenger transport, but due to the negative impacts that urban freight transport has on the urban environment, it is necessary to achieve sustainability in urban freight transport (Behrends, Lindholm, & Woxenius, 2008; Lindholm, 2010).
- **Growing urbanization:** the worldwide urbanization trend is a major contributing factor to the increase of the already significant volume of freight movements in urban areas (Crainic, Gendreau, & Potvin, 2009; OECD, 2003; United Nations, 2005).

2.3 Challenges

The above mentioned increase of complexity of CL leads to a growth of freight volumes and delivery frequencies, which cause several challenges in urban areas. And according to the literature (Ambrosini, Patier, & Routhier, 2010; Awasthi & Proth, 2006; Browne, Allen, Nemoto, & Visser, 2010; L. Dablanc, 2008; Dezi, Dondi, & Sangiorgi, 2010; Goldman & Gorham, 2006) there are seven major problems related to CL:

- Inefficient use of land;
- Physical hindrances;
- Congestion;
- Traffic accidents;
- Low capacity utilization;
- Waste of energy; and
- Environmental pollution.

Urban goods movement have these negative effects that can occur due to insufficient infrastructure, presence of large trucks, *inefficient use of land* used for offstreet and onstreet loading/unloading of goods on vehicles. The presence of freight vehicles causes *congestion* and accessibility problems for other road users, since they act as *physical hindrances*, and they are also a significant cause of accidents, due to their size, maneuverability and on-road loading/unloading operations (Awasthi & Proth, 2006). According to Ambrosini et al. (Ambrosini et al. 2010) there are two types[1] of freight vehicles, the light goods vehicles (LGV) with a mass lower than 3.5 tons and heavy goods vehicles (HGV) with more than 3.5 tons. Despite having different levels of impact, both types of vehicles have negative effects. Browne et. al (Browne et al., 2010) states that since LGVs are mostly used in urban areas, they have a greater impact on urban congestion than HGVs, however HGVs are more responsible for noise disturbance, infrastructure damage (roads and bridges) and vibrations leading to building damages, due to their heavier weight. As it was mentioned before, e-commerce and dynamic inventory management policies are significantly growing, accelerating the growth of small package deliveries; and this associated with the lack of coordination between the shippers and carriers of city logistics leads to *low capacity utilization*, *waste of energy* and empty trips (Awasthi & Proth, 2006; Goldman & Gorham, 2006). *Environmental pollution* encompasses not only ecological problems, such as air and noise pollution, but also visual intrusion or vibration problems caused by HGVs. Urban freight movements represent a quite low proportion of the total vehicle kilometers (10% - 15%), but is one of the top sources of emissions of air pollutants (16% - 50%, depending on the pollutant) (L. Dablanc, 2008; Laetitia Dablanc, 2007).

2.4 STAKEHOLDERS

The relevant stakeholders that have an important influence on the movement of goods within the cities can be roughly divided into five groups (Awasthi, Chauhan, & Goyal, 2011; Benjelloun, Crainic, & Bigras, 2010; Tamagawa, Taniguchi, & Yamada, 2010):

- Carriers;
- Public authorities;
- Receivers;
- Residents; and
- Shippers.

All these institutions, organizations and people involved in CL have their own objectives and interests. The *carriers* are the private or public stakeholders that are responsible for delivering the goods that the *shippers* send to the *receivers*. Their objective is to be competitive by providing the best possible service. *Shippers* have the objective of minimizing the transport costs paid to freight *carriers*. They select which freight carriers they want, and request them to deliver the goods. The *public authorities* represent local, regional or nationwide authorities. Their objective is to resolve conflict between city logistics actors, while facilitating sustainable development of urban areas. The *receivers* are mainly the owners of shops in city centers that are interested in short and reliable deliveries. The *residents* want an attractive and sustainable city with minimum negative effects of urban freight transport.

[1] But Dezi et al. (Dezi et al., 2010) alert that there is a third type of vehicle that has been increasingly used to sort goods: the car.

2.5 EUROPEAN RESEARCH IN CITY LOGISTICS

The growing importance and complexity of city logistics demands the implementation of improvement measures, because if they are not undertaken in the future, there will be the risk of a continuous increase in traffic volumes and a great part (20%) will be due to freight flows (Directorate-General for Research and Innovation of the European Commission, 2010). Therefore there is a need for more and new measures that can be implemented with the objectives of reducing (or solving) the negative impacts of urban freight transport.

The European Commission, under the 7th Framework Programme (7FP), has funded several research activities within the area of transport. This programme allocated €2.22 billion to a total of 620 research and technology projects, from 2007 to 2013, in the area of transport. Within the area of transport, urban mobility is a major priority for the European Union (EU), which is why, since 1998, the EU invested over € 300 million in urban transport research (Directorate-General for Research and Innovation of the European Commission, 2010). Among the 620 projects, the most relevant in the area of city logistics, within the 7FP, include a showcase for good practices of cleaner and sustainable urban transportation (C-LIEGE), a comprehensive approach to urban freight solutions that links urban to interurban freight movements (STRAIGHTSOL), there is also a worldwide perspective of urban logistics concepts and practices (TURBLOG) and finally there is an example that by creating innovative vehicle and transport solutions it is possible to make deliveries of goods within cities more sustainable and efficient (CITYLOG). These projects were chosen because they represent four different approaches to overcome the difficulties and mitigate the problems of City Logistics: a better cooperation between public and private entities (C-LIEGE), encouraging the transferability of good practices between Europe and South America (TURBLOG), creation of a new impact assessment framework to evaluate the application of technological and logistical solutions (STRAIGHTSOL), and finally, the creation of new ways to transport goods with the help of technology (CITYLOG).

2.5.1 CLEAN LAST MILE TRANSPORT AND LOGISTICS MANAGEMENT (C-LIEGE)

2.5.1.1 OBJECTIVES

The main objective of the C-LIEGE project is to enhance energy efficiency in cities by integrated demand management in transport and transferability of good practices/or lessons learned among the EU key players. With the purpose of reaching this objective, C-LIEGE empowers a cooperative approach between public and private stakeholders targeted on the reduction of energetic and environmental impacts of freight transport in European cities and regions, promoting energy efficient and cleaner freight movements in urban areas.

2.5.1.2 METHODOLOGY

This project expected to effectively transfer lessons learned and good practices among Local Authorities (LAs) and relevant stakeholders in EU Member States to reach a better matching between supply and demand of urban freight transport, taking into account the energy saving principles.

From the C-LIEGE project resulted five support tools for Local Governments (Ruszanov, 2013):

1. Urban Freight Transport (UFT) Goods Practices Database: it were collected UFT good practices from a state of the art review of related European projects, studies and initiatives, as well as from the C-LIEGE pilot sites, and also from the project's workshops, which were organized in a manageable and structured database.
2. "Push and Pull" Measures Database: it comprises 45 "push and pull" demand-oriented measures for energy efficient and environmental-friendly UFT planning and management. This database is based on the C-LIEGE analysis of good practices in European countries.
3. C-LIEGE guideline for urban freight mobility plan: it was developed a guideline on how Las can develop urban freight plans as a part of their Local Transport Plan, focusing on how to balance UFT efficiency, energy savings and also minimizing transport negative impacts.
4. Stakeholder Engagement Manual: it comprises advices to public authorities on how to create and manage Local Round Tables, where the relevant stakeholders may resolve potential conflicts and develop common solutions and measures.
5. C-LIEGE toolbox: the objective is to provide procedures for the creation of the City Logistics Manager (CLM), which has the responsibilities of: identifying the problems and needs related to UFT, defining objectives and goals, developing suitable strategies and policies for UFT that comply the local and regional transport plans, defining the appropriate "push and pull" measures to encourage a cleaner, energy saving and cost-efficient UFT control model, and monitoring and evaluating the measures regarding the objectives and goals.

This project tested and shared a set of integrated solutions and "push-and-pull" measures applied to city time slots/space allocation. These measures were implemented in seven pilot experiments in six European countries: Bulgaria (Montana), Italy (Emilia Romagna), Poland (Szczecin), United Kingdom (Leicester and Newcastle), Germany (Stuttgart) and Malta (Hal-Tarxien).

Three measures were applied in all pilot cities (Ruszanov, 2013):

- Creation of a Local Freight Development Plan
- Development of a Local Freight Quality Partnership
- Designation of a City Logistics Manager

And other measures were applied regarding the needs of each city (Ruszanov, 2013):

- Leicester: Creation of a freight map with appropriate routes and vehicle restrictions, sign posting freight routes to industrial estates, it was established an environmental zone, sustainable City Logistics were promoted on the web, and training of freight vehicle drivers on eco-driving.
- Newcastle: development of the Fleet Operators Recognition Scheme, creation of a freight map with appropriate routes and vehicle restrictions, implementation of the Urban Traffic Management Control Centre, creation of the Multi-modal Carbon Calculator, development of the Rail Freight Partner Group, and it was also created an information campaign to reduce accidents.

- Stuttgart: goods delivery with electric vehicles (van sharing), planning of the best location of new lorry refueling station, and ad-hoc routes for freight traffic.
- Szczecin: Creation of unloading spaces, relocation of packsations, creation of an ITS application for re-routing, development of promotion campaigns for sustainable freight transport (eco-driving promotion).
- Montana: creation of different fees for loading/unloading & time windows restrictions, development of a freight map with the appropriate routes.
- Hal-Tarxien: Creation of additional freight parking spaces and re-routing of freight traffic.
- Emilia Romagna Region: Creation of time window and access restrictions for polluting freight vehicles.

2.5.1.3 RESULTS

From the policy session interviews and the impact evaluation presentation it was possible to conclude that the pilot measures were a success. The C-LIEGE project was unique when compared to other projects because it gave the possibility of offering a combination of the measures rather than only implementing the pilot measures and evaluating its impacts afterwards.

Through the interviews that were made in the cities it was possible to conclude that all the actors involved were pleased about working together within the city and with the other cities of the pilot experiments (Ruszanov, 2013).

This project had a great acceptance by all the stakeholders, both private and public, due to the partnership, the collaboration and the will to find new common solutions with an extensive participation of actors.

2.5.1.4 CONCLUSIONS

The C-LIEGE project is an example that a good cooperation between public and private entities is possible. This cooperation was made possible because all the stakeholders involved were open to discuss the conflicts that existed, and together they created the solutions that better served everyone’s interests.

The creation of the City Logistics Manager is an interesting idea because having one person that is responsible for the connection between all stakeholders enables a good and better cooperation among them.

2.5.2 TRANSFERABILITY OF URBAN LOGISTICS CONCEPTS AND PRACTICES FROM A WORLD WIDE PERSPECTIVE (TURBLOG_WW)

The project aims to support ongoing and future initiatives by addressing urban logistics from a worldwide perspective and extending practices and solutions to other countries, with a particular focus on Brazil and Peru where the impact of this research is very significant to regional integration.

2.5.2.1 OBJECTIVES

The objectives of the project were the following (www.turblog.eu):

- Provide a worldwide review of urban freight interventions and data collection techniques;
- Compare different business concepts and models based in the selected case studies;
- Select nine case studies as base for potential transferability: two cases in Europe, three in Latin America and one for the other regions, China, Japan, India and Africa;
- Develop transferability guidelines targeting each type of stakeholder to facilitate the transferring of international case studies to national context.

The overall mission of TURBLOG_WW and its role in EU research can be synthesized as: to put together past urban logistics experiences, analyze them carefully, extract and disseminate valuable information, supporting ongoing and future related initiatives and contribute to its transferability to Brazilian and Peruvian contexts.

2.5.2.2 METHODOLOGY

Develop five regional reports that provide a worldwide view of urban freight measures and data collection methods: EU, Brazil, Hispano-American countries, Asia, Rest of the World (Australia, New Zealand, Canada, United States of America and Africa. These reports include a summary of examples of urban freight interventions, data collection techniques, transport policies, etc (Timms et al., 2010).

Analyze the relationship between different types of business models, the types of logistic profiles and the impact of the measures from the nine case studies. It was possible to identify characteristics of the measures that had positive impacts: which business models were used, its logistic profiles and the policies those results (Rosario Macário et al., 2011).

There were selected nine case studies with different urban logistics profiles (Tromp et al., 2011):

1. Paris, France:
    a. Chronopost Concorde: an Urban Logistic Space was created in an underground parking lot that links a hub outside of Paris to the final delivery, which is carried out by electric delivery vehicles.
    b. La Petit Reine: a company which uses 2 Urban Logistic Spaces that manages the inventory and deliveries orders. The final delivery is done by electrically powered tricycles.
    c. Freight oriented new Urban Master Plan of Paris: the 3 main measures included were the identification of areas that may be used to transship goods from a boat to a delivery vehicle for a certain time, resuming to its normal uses; the designation of specifics areas to develop intermodal logistics activities; and the integration of delivery areas into the premises of the main generators of urban freight flows.
    d. Monoprix Rail Project: a retail group which uses the passenger trains' tracks to partly supplies its stores with trains during off-peak hours.
2. Utrecht, the Netherlands:
    a. Low Emission Zone: an environmental zone where heavy pollutant freight vehicles are not allowed, promoting the use of cleaner ones.
    b. City Distribution Centers: distribution centers on the surroundings of the city to support the deliveries destined to the city. The vehicles that supply the CDCs don't have any

restrictions of size or weight, but the freight vehicles that enter the city have to be environmentally friendly. These green vehicles are allowed to use the bus lanes and have no limitations concerning time windows in the pedestrian area.

c. Beer Boat: the municipality leases the beer boat mainly to companies that supply drinks and food to more than 70 companies along the canals of the city.

d. Cargohopper: a private transport company of the city introduced a new transport mode: the Cargohopper. This vehicle is a multi-trailer, 16 meters long, narrow, solar powered road train, which rides on pneumatic tires.

3. Belo Horizonte, Brazil:
    a. Requirements of loading and unloading spaces inside companies with large traffic movements (large traffic generators): a large traffic generator was defined as a company or a group of companies using non-residential land with an area over 6.000 m2. And these large traffic generators must create areas, places and docks on their landsite for loading and unloading operations.
    b. Internet/telephone sale and deliveries from producer to customer through planned routes: two companies perform the delivery of food products directly from the producer to the final consumer.
4. Mexico City Metropolitan Area, Mexico:
    a. Zero Emissions Corridor in the Central Axis: creation of an access restriction for heavy pollutant freight vehicles and micro-buses on the area called Central Axis.
    b. Freight Transport Regulation Programme for Perimeter “A” of the Historic Centre of Mexico City: time restrictions for freight vehicles greater than 3.5 tonnes. These vehicles are not allowed in the Historical Centre between 7:00 and 22:00.
    c. Vehicle Verification Programme: requirement of vehicle inspections every six months to control the emissions of pollutant and greenhouse effect gases for all types of vehicles (passenger or freight vehicles, private or public).
5. Santiago do Chile, Chile:
    a. Albertis Logistics Park: this is a modern logistics park in Santiago where the principal service is the rental of warehouses. But it is planned to fully work as a logistics centre in the future.
6. Tokyo, Japan:
    a. Shinjuku joint delivery system: this delivery system is characterised by combining truck deliveries and delivery by hand. The truck parks in the first building of its route, where the delivery staff stays to deliver the goods to the different offices in the building, but the truck doesn’t wait for the delivery staff to return. The truck leaves to the next building immediately after unloading the goods, and the delivery staff walks to the next to that building to proceed with the next deliveries. This process repeats itself until the truck reaches the end of its route.
7. Beijing, People's Republic of China:

    a. Beijing Tobacco Logistics Centre: This logistics centre was created to centralize the operations of smaller tobacco logistics centres that were scattered over 18 districts, and to proceed with the distribution of tobacco to the whole city.

8. New York, United States of America:
    a. Off-hour Delivery program Programme: promotion of deliveries during off-peak hours' through a tax break to the receivers that prefer to receive the goods during this time-window.
9. Mumbai, India:
    a. The Mumbai Dabbawalas: the people that have the job of carrying (either walking or by bicycle) and deliver fresh made food packed in lunch boxes are called Dabbawalas in Mumbai. First these lunch boxes (the dabbas) are transported from home or canteens to the rail station, where they are sorted according to their destinations, and loaded on special compartments of the train. The Dabbawalas also regroup according to the number of lunch boxes that are going to a particular area. When the food reaches the designated train station the dabbas are re-sorted again, and the last part of the journey is performed by the Dabbawalas in handcarts to the end customer by lunch time.

The projects defined a transferability approach that consisted of 10 steps (Amaral et al., 2011):

1. Diagnose the problems;
2. Characterize the city;
3. Analyse the city context and implications of problems identified;
4. Search for similar contexts;
5. Select examples of source urban contexts;
6. Identify measures with potential for transfer;
7. Package and dimension the measures for transferring;
8. Ex-ante assessment of measures to transfer;
9. Identify the need for adjustment;
10. Implement measures and steer results.

2.5.2.3 Results

To identify the most suitable logistic solution it's necessary to define not only its business characteristics, but also the logistics profile (delivery, product and city area features) and the policies that will be applied in the city. Only with these three characteristics it is possible to proceed with the decision making for the best urban freight solutions (Rosario Macário et al., 2011).

It was concluded that all the measures of the selected case studies contribute to making the city more attractive and more sustainable. The most common measure is the consolidation of deliveries, and most of these cases demonstrate a growth of productivity and the reduction of the number of trucks needed to perform urban freight transport. The fewer number of polluting freight vehicles leads to the reduction of pollution levels, which generates a more attractive city. According to the case studies of Utrecht (environmental zone), Belo Horizonte (requirements of loading and unloading places) and Mexico City (Freight Transport Regulation Programme and Vehicle Verification Programme), the measures regarding regulations increase the costs, but on the other hand they improve environment, the quality of life, and the city's attractiveness and safety. And the examples of the use of environmentally friendly vehicles, such as in Paris (Chronopost Concorde and La Petite Reine), Utrecht (Beer Boat and Cargohopper) and Mumbai (Dabbawalas), decreases the mileage of polluting vehicles and increases the distance travelled with low-emission transport modes, which improves the environment of the city by reducing the noise and emission pollution (Tromp et al., 2011).

2.5.2.4 Conclusions

The 10 step transferability methodology is very attractive because it is highly city specific. The process focuses upon specific features of the city to which the measure is being transferred, assuming that each location is different, rather than trying to create measures that can be applied everywhere.

2.5.3 STRATEGIES AND MEASURES FOR SMARTER URBAN FREIGHT SOLUTIONS (STRAIGHTSOL)

This project focuses on the challenges regarding freight transport in urban areas. In this area, there have been tested several measures, and whether they are regulatory, technological or logistical measures, they all lack an evaluation framework that can assess their short and long term effects which is a barrier for the transferability of knowledge and best practices. This leads to the need of creating a wide-ranging methodology for urban freight solutions, namely those that link urban to interurban freight movements, which this project aims to satisfy (Nathanail, Gogas, & Papoutsis, 2013).

2.5.3.1 Objectives

The STRAIGHTSOL project has 3 main objectives (Nathanail et al., 2013):

- Create a new impact assessment framework for measures applied to urban-interurban freight transport interfaces;
- Test innovative measures applied to urban-interurban freight operations through seven demonstrations in European cities;
- Assess the results of the demonstrations using the impact assessment framework and develop recommendations for future freight policies and measures.

2.5.3.2 Methodology

The new assessment framework was developed to evaluate measures applied to urban-interurban freight transport interfaces. This framework includes multiple methodologies that stress the involvement of various stakeholders in the decision process, as well as on the measure impact on society and private sector. The framework was planned to be used by both private companies or public administrators (local, regional or national level), and it has the possibility of being used in the different stages of the decision making process.

The STRAIGHTSOL project demonstrates new solutions for smart and sustainable urban-interurban transhipment and last mile distribution, through the application of seven demonstrations (Andersen, Eidhammer, Milan, et al., 2012):

1. DHL Supply Chain's Urban Consolidation Centre in L'Hospitalet de Llobregat - Barcelona (Spain): The key objective is to concentrate goods for the urban distribution in order to improve the efficiency of the last mile network. The demo started on February 2013.
2. TNT Express in Brussels - City Logistics Mobile Depot (Belgium): The idea is to make use of a mobile depot which is a trailer fitted with all depot facilities combined with electrically supported tricycles to accomplish the last mile distribution. The demo is expected to start on May 2013.
3. Oxfam - Remote 'bring-site' monitoring for more reactive and sustainable logistics (United Kingdom): A subset of Oxfam's textile banks are equipped with remote monitoring technology (Smartbin sensors) to observe daily fill rates and thus facilitate better trip planning and collection from the banks. This demo started on June 2012.
4. Kuehne + Nagel - rail tracking and warehouse management (Greece): The objective is to monitor freight wagons destined for Thessaloniki by use of the global positioning system (GPS) to inform the warehouse management system on the freight arrival, facilitating more efficient planning of last mile deliveries. The demo started in August 2012.
5. GS1 - Smart Urban Transport Solution - Retail supply chain management and 'last mile' distribution by use of standardised information and buffer storage (Norway): The demonstration showed how automatic data capturing and sharing together with use of buffer storage contribute to more predictable deliveries and shorter delivery times. The demo took place on October and November 2012.
6. Off-hour deliveries: The demonstration will show the possibilities and impacts of off-hour deliveries. The demonstration will start in the second half of 2013.
7. Loading/unloading operations management and regulations Lisbon (Portugal): This demonstration has tested and identified technologies for controlling and monitoring cargo loading/unloading in the urban context. The demo ran from December 2011 to April 2012.

2.5.3.3 Conclusions

The results of STRAIGHTSOL represent innovations in three directions. First of all, the demonstrations are innovative and represent cutting-edge initiatives covering, e.g.:

- New transport solutions;
- Optimization of terminals connecting long-distance transport and urban distribution;
- New regulatory solutions;
- New instruments / technologies for urban freight data collection;
- Collaboration between authorities, transportation providers and major customers.

Secondly, the STRAIGHTSOL evaluation framework represents an innovation. This framework is generic and applicable beyond the project, it captures different stakeholder perspectives, combines different methods addressing different questions and it can be adapted to different levels of ambition.

Thirdly, the project will lay the ground for transferability and roll-out of the demonstrated solutions. The project lays strong emphasis on the exploitation and the actual use of the project results which is facilitated by:

- The emphasis on multiple stakeholder perspectives;
- The in-depth study of business aspects and potential business models for roll-out solutions;
- The considerations on preconditions for and barriers to success within the analysis of roll-out of the solutions.

2.5.4 SUSTAINABILITY AND EFFICIENCY OF CITY LOGISTICS (CITYLOG)

This project was created with the purpose of making deliveries of goods within cities more sustainable and efficient with the application of integrated mission management and by creating innovative vehicle and transport solutions. The CITYLOG project is addressed to five main stakeholders' groups: Freight Carriers, Vehicle Manufacturers, Administrators, Residents and Shippers.

2.5.4.1 OBJECTIVES

The CITYLOG project proposes three ways to improve today's city logistic system (Corongiu, 2013):

- Logistics-oriented telematics services: the use of Intelligent Transport Systems can improve the mission planning processes by optimizing the routes and providing a better support system to the drivers. And regarding the final customers, the number of unsuccessful deliveries can be reduced with the introduction of tracking and tracing technology.
- Vehicle technologies: enabling freight vehicles to perform different tasks, which will increase their operational flexibility and therefore achieve a better interoperability among the vehicles, will allow a reduction of their number.
- New load units: a flexible internal layout would enable it, like the vehicles, to operate in different missions, whether as a simple container or a mobile pack station.

The innovative approach allowed a reduction of the number of vehicles performing deliveries in urban areas and an optimization of their use. The projects' solutions and technologies allowed an increase of energy efficiency and quality of services, which are of highest interest to logistic freight operators.

2.5.4.2 *METHODOLOGY*

In a first stage the project studied the main trends in city logistics and the stakeholder's needs, and then defined the most significant use cases that would be used in the implementations.

It was projected a common architecture to integrate the four telematics solutions proposed:

- Pre-trip planner: New planning functionality algorithm for freight bus and delivery vans.
- Ad hoc map attributes: New map attributes for urban freight transport: environmental restricted zones; access restrictions; delivery time windows.
- Dynamic assisted navigation: A server with a route calculation system and a database with real-time traffic information.
- Last mile parcel tracking (LMPT): The LMPT service was in charge of managing messages coming from the CITYLOG components. A message contained the estimation time of arrival message and information on the parcel receiver (address and phone number) was elaborated by the LMPT application. An SMS was sent to the parcel receiver in order to communicate the time of arrival and the address confirmation.

Figure 2.1 - CITYLOG ITS architecture. Source: (Corongiu, 2013)

The innovative vehicle and load units that resulted from this project were:

- Freight bus: 16-tonne trucks that were able to load and unload 3 load units and were equipped with vulnerable road user detection system.
- Distribution van: freight vehicle dedicated to urban distribution with the capacity to load and unload 1 load unit, and equipped with a telematics unit and a pedestrian detection system.
- BentoBox concept: A pack-station which allows great flexibility in the delivery process by separating the courier driver activity and the receiver activity. This way the courier can place a set of parcels in the BentoBox drawers; the Bentobox software keeps track of the parcel positions within the different drawers; customers can collect their parcels in an autonomous manner by being given username/password and entering the consignment number(s) in the touch screen.

The CITYLOG logistic model was based on the freight bus, delivery vans and containers (load unit) with extensive legs. The first would make the connection from a hub outside the city to the city-center with 3 load units; a delivery van would load each load unit in a logistics platform called “transshipment” and then perform the deliveries and collection of new parcels. After these operations, the distribution vans would return to the logistics platform and the load units would be loaded to the freight bus that would return to the hub (Corongiu, 2013).

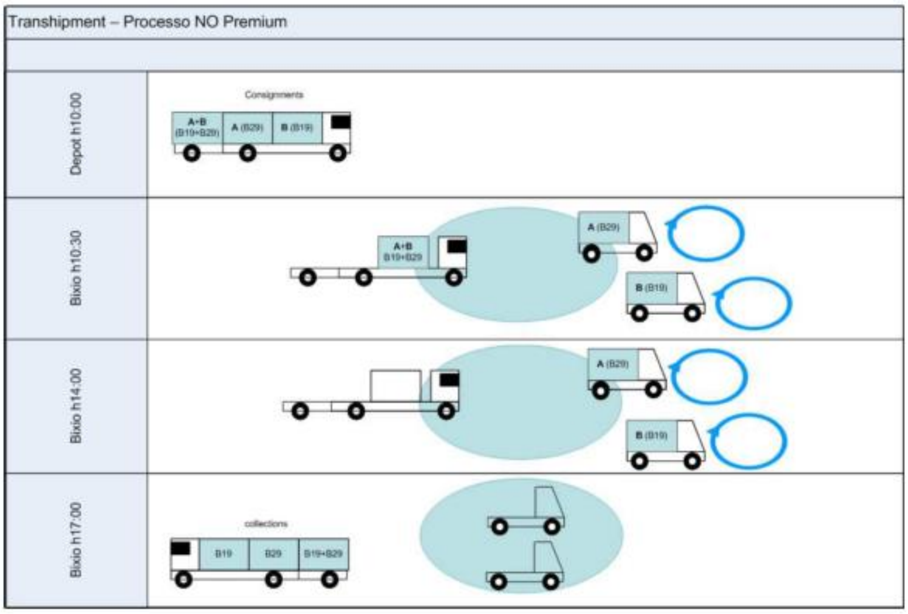


Figure 2.2 - Transhipment trials in Turin

The second stage of the project was dedicated to the deployment and testing of the CITYLOG solutions in three European test sites: Lyon, Berlin and Turin. The results of the test sites were then analyzed, and it was also assessed the impact and business perspectives.

The four ITS solutions were tested in the three cities. The loading/unloading functionalities were demonstrated and fully validated both in the freight bus and in the distribution vans. In Lyon and Turin it were tested the operations of vehicle-to-vehicle transshipment. And the load units with extensible legs and the BentoBox were tested in all three cities.

2.5.4.3 RESULTS

The project defined a list of recommendations:

- The group that includes Local Administrators, Carriers and Residents, has an interest in measures that allow efficiency improvements of the utilization of the available road capacity among the road and non-road users.
- Policies of accessibility restrictions and reallocation of road spaces (priority lanes or delivery areas) should be used to avoid conflicts.
- There is a preference for the creation of freight plans and ITS solutions for city logistics, over road pricing measures.
- Local Administrators and Residents expect the urban freight vehicles to be clean, silent and safe.

- There is a need for urban freight vehicles and their drivers to be assisted by ITS equipment, and the vehicles should have a right-sized and flexible cargo capacity.

2.5.4.4 CONCLUSIONS

The CITYLOG project came up with an innovative approach of dealing with City Logistics' problems: combine the use of technology with creativity, in order to improve urban deliveries, making them more sustainable and efficient. The technology part refers to the use of telematics solutions, and the creativity part refers to the re-thinking of the layout of the internal storage of the freight vehicles, which was named the BentoBox Concept.

2.6 CONCLUSION OF THE CHAPTER

In conclusion, there are several definitions of CL in the scientific literature, but in this work it was chosen the one (from the author Stathopoulos *et al.*) that better describes the author's understanding of the City Logistics concept.

The concept of CL was not needed only in the modern world, as it already existed in Julius Caesar's Roman Empire, which shows the importance and significance of CL. With the growing complexity of CL, there was a growth of the interactions between the relevant stakeholders that caused the appearance of several problems regarding the transport of goods in urban areas.

The European Union and the European Commission are aware of the importance of CL and its challenges, therefore they have funded several research activities in the area of transport in order to test new and innovative approaches to deal with the problems of CL. The author is aware that there were other research projects that were funded by the European Commission under the 7th FP, but it is the author's opinion that the examples presented give a wide overview of the possible approaches to overcome the problems of CL. Thus, the next chapter explains which categories of CL measures exist and gives examples of each of them (some of which were part of other European research projects).

3 EXAMPLES OF CITY LOGISTICS MEASURES

3.1 CITY LOGISTICS MEASURES

Coherent urban freight transport measures have not been developed to the same extent that they have for passenger transport. However many urban authorities have begun to focus far greater attention, over the last decade, on the efficiency and sustainability of freight transport within cities, due to its economic importance. (Cherrett *et al.*, 2012)

Efficiency improvements of UFT can benefit both freight transport companies and the wider society, because UFT plays a major role in competitiveness of urban areas both in terms of generated income and employment. But on the other hand, adopting policies that ease urban goods movement may increase the volume of freight vehicles in cities, which has negative effects on the environment such as congestion, air pollution, noise and increases the logistics costs, and hence product prices.

The scientific literature reviewed by the author revealed several different measures that are used to improve the logistics of urban freight transport. The author will follow the classification scheme used by Muñuzuri et al. (Muñuzuri, Larrañeta, Onieva, & Cortés, 2005) that divides the measures in five groups:

- Public infrastructure;
- Land use management;
- Access restrictions;
- Traffic management; and
- Enforcement and promotion.

The *public infrastructure* measures have the objective of developing new or extend existing infrastructures. Introducing an urban hub or new roadways are common measures used to facilitate urban distribution. This group includes measures that aim to encourage modal shift towards more sustainable modes, like the use of railway for long-haul transportations or subway systems for inner city transportations (Muñuzuri et al., 2005; Stathopoulos et. al, 2012).

In European cities, the measures related to *land use management* can be very difficult to implement because urban areas have narrow streets inherited from the Middle Ages, but there are some examples such as zoning of commercial and residential activities to encourage initiatives such as load consolidation (Stathopoulos et. al, 2012). The first two groups of measures cannot be clearly separated, and examples that support this idea are the loading/unloading parking bays, multiple use lanes or parking space planning (Muñuzuri, Cortés, Guadix, & Onieva, 2012). However, in this work, these three examples are going to be included in the group of the *land use management*, because they exemplify a change of the land use in order to provide a better management of the city logistics' activities.

The group of *access restrictions* has many different types of measures. The most popular are related to time restrictions and restrictions referring to capacity utilization, emission levels, size and weight. Regulations on delivery time windows, especially for pedestrian zones, are also common measures used in many cities. These types of measures are imposed by the local authority which impact on freight operations (Muñuzuri et al., 2005; Stathopoulos et. al, 2012).

According to Muñuzuri et al. (Muñuzuri et al., 2012) *traffic management* measures have the purpose of reorganize and facilitate the flow of urban goods movements with the objective of reducing the negative effects associated with traffic congestion. These measures aim to achieve the safe and efficient movement of road users, whether private or commercial; and they are needed because many road users act inappropriately to the road conditions in which they find themselves (Abel & Karrer, 2006). Examples of this group of measures include the Intelligent Transport Systems, introduction of delivery lanes or road pricing.

Another important area that can enhance the efficiency of the City Logistics is the *enforcement and promotion*. This group of measures is intended to work together with the others creating combined solutions (Muñuzuri et al., 2005). Local authorities can use promotion tools to support specific practices without the need to impose them, while the enforcement tools are used to guarantee that the regulations are obeyed. Some examples include law and regulations enforcement (Rosario Macário et al., 2011), however most popular are the measures related to parking enforcement. Other examples of this type of measures include the use of technology to improve parking spaces' monitoring, the use of the internet to schedule the use of loading/unloading bays according to the user needs, and real-time recognition of vehicles with cameras or sensors.

One popular CL measure that cannot be assigned to only one of the five groups, due to its nature, is off-hour delivery. The objective of this measure is to decrease the number of deliveries made during daytime, which can be enforced, for instance, by prohibiting city access for freight vehicles during the day, but can also be achieved by reducing road pricing in non-congested hours. According to Holguín-Veras (Holguín-Veras, 2008) the second option (using road pricing) is not very effective to enforce the switch of freight movements to non-congested hours. But the option of using time window and vehicle restriction are very effective and very popular in Western Europe (Quak & de Koster, 2007). However Van Duin et al. (van Duin, Quak, & Muñuzuri, 2010) stated that time restrictions only have limited effects. Despite the different authors' opinions about the introduction of these measures, they seem to play an important role in achieving a more sustainable distribution.

Public authorities can implement the mentioned CL measures to ease urban freight transport. These measures should be adjusted to the city own needs in cooperation with the relevant stakeholders.

3.2 PUBLIC INFRASTRUCTURE

This category of CL measures is related to those that develop new or extend existing infrastructures. It will be presented 3 examples of this type of measures.

In Switzerland we have an example of a modal shift, where the tram network is used to collect the bulky waste, instead of the traditional waste trucks. The other two examples come from two Italian cities: Padova and Lucca. And both use an urban distribution center that manages and organizes the deliveries to the city center.

3.2.1 CARGO-TRAM AND E-TRAM, BULKY ELECTRIC WASTE COLLECTION BY TRAM IN ZURICH (SWITZERLAND)

The Cargo-Tram service was introduced in April 2003 to provide a car-free option to Zurich residents who need to dispose of their bulky waste. Three years after, in 2006, the E-Tram was created to provide a similar service for the removal of electrical and electronic waste. Nowadays, these two services make about 18 round trips every month. This is a free service (Chiffi, 2006).

3.2.1.1 Background and Objectives

Before 2003 there were only two options for disposing bulky waste in Zurich: load the bulky waste to your own car, drive to the dump burning power plant and pay 20€; the other possibility was paying 27€ to the bulky waste service and they would remove it from the front of your house. But with the creation of the Cargo-Tram service, the situation has improved: the residents of Zurich carry the bulky waste into the next bus or tram and drive to one of the 9 cargo-tram pick-up points and leave it there, for free. The dump and bulky waste is then organized by workers of the “Remove and Recycle” program to fill two containers, which is afterwards brought to the dump burning power plant.

The city disposal service is the ERZ (Entsorgung und Recycling Zürich). Now this city has one paid option (bulky waste can be collected at a charge) and another that is free (this type of waste can be left at one of the two ERZ yards for free). The objectives behind the idea of a freight tram were to have a more attractive and inexpensive collection service and also to avoid ERZ door-to-door trips, private car trips to disposal yards and illegal dumping of bulky waste items (Chiffi, 2006).

3.2.1.2 Implementation

The project was implemented with the collaboration of the city public transport operator (Verkehrsbetriebe Zürich- VBZ). The Cargo-Tram consists of two adapted refuse containers are carried on four-wheeled flat wagons and hauled by an old tram. The public transport operator invested 25,000€ for the adaptation of containers, tram’s livery and the low cost infrastructure of the shops. The Cargo-Tram service has a daily cost of 1,000€. There are two restrictions on the consigned items: may not be longer than 2.5 meters and can’t be heavier than 40 kg per piece.

The E-Tram was introduced in January 2006 which uses another adapted freight tram for the disposal of electronic and electric waste.

Today both services make a total of 18 round trips every month, and each trip serves one of the 9 pickup points. Cars don’t have access to the 9 stops during their working hours (from 3 pm until 7 pm) (Chiffi, 2006).

3.2.1.3 Conclusions

The introduction of the Cargo-Tram and E-Tram was not surprising for Zurich residents: it’s a city that has 385,000 inhabitants and 165 km tram network, and 43% of household waste remains in the recycling process (Chiffi, 2006).

3.2.2 PADOVA CITYPORTO: A SUCCESS MODEL OF URBAN LOGISTICS (ITALY)

Figure 3.1 - Cityporto project in Padova (Source: www.cityporto.it)

3.2.2.1 BACKGROUND AND OBJECTIVES

One of the objectives defined by the Veneto Region in 1999 was reducing air pollution in urban areas. In Padova, the Interporto Padova S.P.A., one of the most relevant logistics operators in Italy, has been operating for many years. It was in this context that the Padova Cityporto project was implemented in 21st April 2004. There was an agreement between the Province, the Municipality, the Interporto Padova S.P.A., the Local Chamber of Commerce and the local company for mobility planning, APM Mobilità. Other relevant supporters were the Ministry of Environment and the Veneto Region. Since the implementation of the project there has been a significant participation of the stakeholders. The interests of both public and private entities have to be taken into consideration, which makes the management of city logistics a sensitive issue, but the aim is to have all stakeholders working together in the best and most effective way (Galli, 2012a).

3.2.2.2 IMPLEMENTATION

Freight transport operators can either choose to join the Cityporto model, which provides an easier access to the city centre for freight delivery, or else they can continue to access the city according to general time-slots.

Those that decide to join the Cityporto project have to deliver their goods to a dedicated logistics platform in Interporto Padova. The management of the daily delivery plans are supported by ITS technologies: Cityporto eco-friendly vehicles are responsible for covering the “last mile” in the most agreeable conditions, with the best loading capacity and lower delivery trips possible.

Cityporto vehicles are allowed to (Galli, 2012a):

- enter the city 24hrs a day;
- use reserved public transport lanes;
- use dedicated loading bays for their load/unload operations.

A total of 55 operators have joined the Cityporto scheme, which is based on a fleet of 10 vehicles (hybrid and CNG) (Galli, 2012a).

3.2.2.3 CONCLUSION

In 2005 the scheme delivered about 190,000 items, and the volume of activity is almost the double of that number, with a peak of 397,000 deliveries in 2008. The average of items per delivery has been growing and is now 6.6 packs per delivery (Galli, 2012a).

The Cityporto project allowed the achievement of great improvements in environmental conditions, as it was confirmed by a recent study of the Ministry of Environment on the Cityporto's activity over a two year period (2008-2010). With the project's fleet of eco-friendly vehicles It was possible to reduce the total amount of kilometres covered by freight vehicles from an average of 1,052 km per day in the second semester of 2008, to 1,216 km per day in the beginning of 2010. It was also avoided the entrance of 100 pollutant vehicles (Euro 1 and Euro2) in the city every day, which has contributed to a significant reduction in pollutant emissions emissions (-219 tonnes of $CO2$, -369 kg of NOx, -72.8 kg of SOx, and -51.4 kg of PM10) (Galli, 2012a).

The key success factors of the initiative were:

- stakeholder involvement from the early stages of the project has led to shared decisions about the kind of service to be implemented;
- the industrial plan was focused from the beginning on the economic sustainability of the activity, so gradual steps have been planned which have led to increased growth of the service;
- last but not least, the key-role played by the freight village Interporto Padova. The best solution for this role is to choose the right implementer, such as a logistics/transport operator partly owned by a public entity, as it was in Padova, or other public companies managing mobility services in the city.

The next step for Padova Cityporto is to expand the service to express–delivery, which is booming because of the wide and continuing spread of e-commerce.

3.2.3 URBAN LOGISTICS INNOVATION IN THE MID-SIZED HISTORICAL CITY OF LUCCA (ITALY)

3.2.3.1 BACKGROUND AND OBJECTIVES

The city of Lucca created a comprehensive sustainable mobility scheme with the objectives of reducing the emissions of noxious gases and noise, traffic-related energy consumption, and therefore preserving its tourist and historical assets. The scheme was created with the implementation of specific regulatory initiatives, telematics infrastructures, and improvements of the quality of public transport as well as city logistics processes under environmental preservation constraints.

The historical centre has approximately 1,500 shops and other businesses, which attract a significant amount of freight vehicles (a daily average of 700 freight vehicles to enter the centre per day). A substantial part (27%) of the businesses in the area uses their own vehicles to do the freight transport. And the general part of the freight deliveries is made by vehicles with low capacity usages (less than 30%).

The Municipality started to investigate new solutions to improve the freight transport in the city, which would be accomplished by rationalising the entire distribution system, leading to fewer journeys and better use of available vehicle capacity, and by reducing the impacts and externalities of traffic flow in the area (Galli, 2012b).

3.2.3.2 Implementation

A Centre for Eco-Friendly City Freight Distribution (CEDM) is based on a City Distribution Terminal as a main infrastructure to support rationalised, eco and business-efficient urban distribution. The CEDM has the need of implementing transport and mobility measures like: time and access restrictions to the historical centre (a time slot for each type of good, minimum load factor, electrical vehicles for final deliveries); to meet the access requirements and economic efficiency of the last mile city distribution it was needed a cooperation between the freight operators; citizens and tourists were able to use innovative delivery concepts including goods delivery via dedicated collect points; and last but not least, it was needed to manage efficiently the reverse logistics.

Periodic surveys are made to monitor the quality and efficiency of the service, energy consumption and CO2 emissions, social-economic aspects, customer satisfaction and the impacts on the urban environment. Results show that the eco-friendly services provided by CEDM platform have a very good acceptance and they are preferred to the traditional service with diesel vehicles.

The volume of transported goods and the number of deliveries have been constantly increasing, which translates in a growing activity of the CEDM platform that is now integrated into the service called "Luccaport". It was expected that the service would reach 80% of all deliveries in the area by the end of 2013 (Galli, 2012b).

There was a reduction of the polluting emissions in the urban area due to a decrease of the freight traffic flow that followed the implementation of the CEDM and the use of eco-friendly vehicles, which led to the enhancement of the quality of life in Lucca's historical centre.

The Italian Energy Agency ENEA foresees two possible scenarios: the less restrictive predicts that the CEDM system will lead to a reduction of about $1/3^{rd}$ of the freight traffic in the historical centre; and the other scenario implies a reduction of about 2/3rds of the not eco-friendly traffic in the historical centre. With these two scenarios in mind, the evaluation of the CEDM actions show the following emissions reductions: 34 to 79%; PM-reduction: 38 to 76%; NOx-reduction: 39 to 75%; VOC-reduction: 22 to 86% (Galli, 2012b).

3.2.3.3 Conclusion

With this project in Lucca it was possible to show that an integrated and innovative approach to city logistics can have a relevant and positive impact on the environment by reducing its negative effects, and can also contribute to sustaining the management of the movement of goods and people in urban areas. An initiative of this type has to include all the stakeholders involved in order to be successful and must address all of the different aspects related to urban management (e.g. mobility policies, political and social aspects, technological and infrastructural issues).

The CEDM project proves that local authorities that are vigilant, have a long term perspective and are focused on efficiency and reality can reach goals above their expectations.

3.2.4 CONCLUSION

In conclusion, it is possible to use existing public infrastructures to improve CL. Sometimes it is needed to change the use of the infrastructure in order to overcome existing problems, and the results of the project in Switzerland point out that the population (at least Zurich's population) are open to these changes. There is also evidence that both public and private stakeholders are open to discussion and are willing to reach a consensus that benefits all parties involved, which was what happened in the Padova's CityPorto project.

Most historical cities have narrow streets and were not designed for the use of the car; therefore most of these cities have problems related to freight deliveries to the city centre. In these cases, municipalities have the need to create a hub that centralizes and manages all deliveries to the busiest areas of the city.

3.3 LAND USE MANAGEMENT

This group of measures refers to those that manage the land use in order to reach a better organization of the city logistics activities.

First, we have an example from the German city of Bremen where an environmental loading point was created inside the pedestrian area, which only allows clean delivery vehicles to park. After that it is given an example from Reims, in France. In this highly dense French city it was created a system with ITS that controls the delivery times of freight vehicles, allowing a maximum of 20 minutes for each vehicle. In another French city, Poitiers, is the example of changing the use of a car park, giving a time-window to delivery vehicles and the other to short-term parking (maximum of 10 minutes, for free). The Poitiers authorities have ITS solutions that monitor all the parking spaces. Finally, the last example is in the Danish capital. In a school located inside a residential neighbourhood, it was given a double usage for the parking spaces nearest to the school entrance: during the day only bicycles are allowed to park, after which only cars can park.

3.3.1 ENVIRONMENTAL LOADING POINT FOR INNER CITY DELIVERY IN BREMEN (GERMANY)

3.3.1.1 BACKGROUND AND OBJECTIVES

The PARFUM pilot project in Bremen, which finished in 2009, was named Environmental Loading Point (ELP) and gave some operational incentive for clean delivery vehicles.

This ELP was located at the edge of the pedestrian area and gave exclusively for clean delivery vehicles extended time access to the pedestrian area - to conduct deliveries and pick-ups (in addition to existing unrestricted time windows for conventional vehicles). This was seen to offer a strong economic incentive (as opposed to a restriction) to operators using Environmentally enhanced vehicles (EEVs), first through a reduction in the number of vehicles necessary to serve the area, and second through the offering of improved service hours that bear a particular benefit also to inner city commerce.

3.3.1.2 Implementation

This ELP is located at the edge of the pedestrian area (as can be seen on the Figure 3.2) and gives extended time access to the pedestrian area exclusively for clean delivery vehicles.

The registered users received a vehicle based allowance for the use of the point and an RFID transceiver for authorization measures.

The system works as follows: when a vehicle enters the point the induction loop under the pavement registers the movement and the RFID sensor above the traffic light will try to communicate with the on-board RFID transceiver. If the vehicle has a transceiver, nothing will happen and the user is welcome to park on the point and start unloading the shipments. Otherwise, if the vehicle doesn't have a transceiver, the traffic light begins to shine orange, which indicates an unauthorized parking. Additionally, there are traffic signs which explain the ELP, which is another part of the enforcement against parking violators (PARFUM, 2008).

(Source: PARFUM, "D.C.3: Bremen Results Report")

Figure 3.2 - The Environmental Loading Point in Bremen

3.3.1.3 Conclusions

It was not possible to obtain the results regarding the Environmental Loading Point, since the results are generic and refer to the all the measures implemented in Bremen during the PARFUM project. But in general, it was achieved an emission reduction of the polluting gases Nox and PM10. This reduction was estimated at 1.065.300g of Nox and 74.370g of PM10 (PARFUM, 2008).

This is an interesting pilot, because it uses technology to monitor the loading and unloading operations on a delivery bay. It describes the technology used, and it appears to be easy to implement (it consists of only a RFID sensor and a transceiver, and an induction loop). And it is different of the other projects because this is an incentive to the delivery vehicles, rather than a restriction (more common).

3.3.2 CONTROL OF DELIVERY AREAS IN REIMS (FRANCE)

3.3.2.1 BACKGROUND AND OBJECTIVES

Reims is one of the highest density French cities, so there are daily congestion problems. The situation of deliveries becomes more and more problematic and the respect for the delivery areas became less and less effective. The main problem for delivering takes place during peak hours, when individual cars and public transports share the road with freight transport. The problem for deliverymen is to find a place to park their vehicle that provides good conditions to work.

The main objective was to reduce congestion and to reach a better usage of different user interest (logistics companies, shop owners, residents and private car-users). Because of those reasons a time restriction scheme has been introduced that foresees time delivery windows for each delivery vehicle entering the inner-city area (Littiere, 2006).

3.3.2.2 IMPLEMENTATION

A new technology based on a floor system has been introduced to regulate and monitor delivery actions in the inner city of Reims. That technology recognizes the presence of a vehicle that enters the delivery area and once the vehicle is parked a stop watch starts for 20 minutes (the time allowed is 15 minutes). After that period, a twinkling panel (2 meters high), lights on.

The control of the delivery areas is assured by municipal traffic wardens.

All information from on-street parking meters are linked to a central data center. A modelling system allows knowing the average number of car parks occupied. So, if police agents observe a difference between the model and the observation (less than forsaken), they go on the site in order to check if the deliveries area is correctly used.

In the first period of using this new system the municipal traffic wardens observed a growing of the entries of charge. But after that people understood the system and thanks to a better action of police agents, the infringements slew down, and delivery areas started to be more respected (Littiere, 2006).

The experience in Reims gave satisfaction, it was not so expensive and the results were positive. However, the number of places equipped by that system was quite weak and only on the city center.

According to the local authority, the technology was not very expensive. It was included in the global budget of the street management (including panels, maintenance of the road and pavements) (Littiere, 2006).

3.3.2.3 CONCLUSIONS

By 2006, the system was already in function for 2 years, and it was qualified as “efficient” by the mayor. However, observation of the vehicles not respecting the system was still manual and there was no possibility for traffic wardens to control the car parks in the whole city at the same time (Littiere, 2006).

As future developments it was planned, in a short-term, that the system should be developed in the whole city center; and in a mid-term, the project consisted in linking one-street parking meters to a control center, with the aim to develop a traffic wardens mobile unity which could intervene thanks to a system which keeps informed the police units.

3.3.3 DYNAMIC DELIVERY AREAS IN POITIERS (FRANCE)

3.3.3.1 Background and Objectives

During the renovation of the main railway station in Poitiers, a car park near the station (where numerous shops are) has been reorganized in order to propose an experimental dynamic control of parking uses.

3.3.3.2 Implementation

The local governments of Poitiers in 2007 set up a dynamic system of on-street parking space use: parking spaces are reserved for deliveries between 5:00-11:00 am, and outside of this time slot, the spaces are used for short term car park (10 minutes, free). The municipality controls the use of the spaces from a distance (INRETS, Leonardi, Levifve, & Simeoni, 2010).

The vicinity of the train station included 124 spaces of "minute" stops and 760 parking spaces to facilitate short-term car parking near the shops, while facilitating deliveries (75 deliveries / week). There were settled 23 inter active bollards. Each bollard cost from 3000€ to 4000€ (INRETS et al., 2010).

The principle is simple: a sensor is put in the ground; it detects the presence of a vehicle. On the bollard, a screen displays the authorized park use currently operational (which is delivery or private car parking). When a vehicle is present, the time of authorized parking is displayed on the bollard. If the car is not moved within 10 minutes, a SMS is sent to the local police so that it moves the car (INRETS et al., 2010).

More than 40 vehicles actually use one parking space between 8 am and 8 pm:

- 74 % of cars park for less than 10 minutes
- 48% for less than 5 minutes
- On the 26% cars breaking the time rule, 63 % leave in the 5 minutes after receiving the first alert.

3.3.3.3 Conclusions

The display of a possible fine on the bollard’s screen is good for enforcement.

Such an experiment is interesting because it obliges space users (cars or delivery vehicles) to abide by the rules. An efficient link between the system and the police is necessary.

The main problem can come from the weak availability of the police services which cannot spend time with car parking issues.

Bollards are not very expensive. They can be implemented in all critical sites where numerous vehicles have to share the space (near train or major bus stations, city centers).

3.3.4 SHARED (PARKING) SPACE FOR BIKES AND CARS IN COPENHAGEN (DENMARK)

3.3.4.1 BACKGROUND AND OBJECTIVES

In Denmark, there are many car parking spaces that are being transformed into bicycle parking, which reduces the number of car parking spaces but that is not necessarily a negative thing. With the help of consultants from Atkins Danmark, the City of Copenhagen decided that it would be possible to say “yes” to both bikes and cars, rather than saying “either/or”, and created the concept of “flex parking”.

Figure 3.3 - Flex parking logo
Source: (ATKINS, 2012)

This concept is based on the idea that both cyclists and motorists can access the parking space at different time, which is why it was chosen a High School to test the “flex parking”, the Ingrid Jespersen High School in Copenhagen. The pilot started in 2011 and it were used 5 car parking spaces to test the acceptance and usability of this concept (Rusanen, 2011).

3.3.4.2 IMPLEMENTATION

In Copenhagen, most of the students go to school by bike, but they only stay at school during a limited period during the day. Since the High School where the pilot was implemented is located in a residential area with many car owners, the demand for car parking spaces rises at night, when people come home from work. This results in two different needs of the same space throughout the day, which is exactly what makes possible the concept of “flex parking”.

To implement the pilot project, the parking spaces that would be used as “flex parking” were marked with the logo. There were also installed signs indicating when cyclists and motorists could park on those areas. The new regulation states that from 7:00 to 17:00 the space is allocated to bikes and from 17:00 to 7:00 can only be used by cars. In order to disseminate the pilot, a pamphlet was distributed to students and residents, so that both cyclists and motorists knew the new when and how they could use the parking spaces.

The costs for development of the pilot project were 172,500 DKK (approx. 23,125€). In future, the implementation costs are foreseen to be approx. 30,000 DKK (approx. 4,022€) (Rusanen, 2011).

3.3.4.3 CONCLUSIONS

Flex parking may not be 100% ideal for cyclists, as there are no bike racks; nor 100% for motorists, who have to respect the time limit. But the pilot received a good feedback from everyone: students, their parents, school personnel and citizens in the area. Since both parties – not just one of them – get a parking option, the project solves the parking problems around the school.

Only around the times when the area switches from bicycle parking to car parking or vice versa there are some minor problems. Sometimes there is still a bike or a car that has not been removed, but it didn’t cause any accidents. In the future, it is important to determine the time limits that match the needs of both user groups.

Since this is a well-known and challenging problem in many Danish cities, the project naturally received much publicity in the press. The city of Copenhagen has 7 other schools that want to try this new concept of flex parking, and there were also identified a total of 17 places where this concept of parking could be implemented, including those other schools and even supermarkets.

This pilot project has shown that it is possible for both cyclists and motorists to share the same parking space.

3.3.5 CONCLUSION

Monitoring parking bays can be eased with the use of technology. It simplifies the work of the enforcement entities and it encourages the users to be more responsible when using these areas to park. The technologies that make the monitoring a more automatic process are not very expensive. The first three examples that were given make use of technology to identify the vehicles that use the parking bays and to control the parking times of each vehicle. However, the last example (in Denmark) has a different approach to the problem, and without the use of technology achieved good results in the management of the use of the parking bays by adapting the permissions to park to the demand during every period of the day.

3.4 ACCESS RESTRICTIONS

The most popular measures of *access restrictions* are time restrictions and restrictions referring to capacity utilization, emission levels, size and weight.

The first example given is from Enschede, in the Netherlands, and it is an example of time restrictions. In the French city of Montpellier, it was devised a schedule of access restrictions to the city center, where the electric vehicles are the ones that are preferred to circulate in this area of the city. The city of Maribor, in Slovenia, introduced an access restriction for delivery vehicles.

3.4.1 ACCESS RESTRICTIONS IN ENSCHEDE (NETHERLANDS)

3.4.1.1 BACKGROUND AND OBJECTIVES

The municipalities responded to the operators' call for delivery window alignment by starting cooperation between the municipalities. Transport operators were faced with different rules and access restrictions, which was costly (in time and money). The differences in rules between municipalities were significant, which in some cases meant that it was needed to use different trucks for delivery rounds, instead of one. The lack of enforcement of the delivery windows, which made them rather ineffective, was the reason for introducing the bollard system with vehicle identification by video (Rasch, 2006).

With the new system of access restrictions, the municipality of Enschede wanted to create a safe and pleasant inner city. The access restrictions minimized the negative external effects (pollution, congestion, etc.) caused by delivery trucks within the city center and shopping areas, while maintaining the possibility of supply to the firms and industry within the city center.

3.4.1.2 Implementation

The inner city of Enschede (including the shopping area) is closed for all traffic between 11 am - 7 am. These opening times are enforced by a bollard system. This system functions with an access pass combined with license plate identification (by video). This method of identification is used solely for trucks and taxi cabs.

The municipality of Enschede is using a bollard system to close the city center for all traffic. To visit the city center outside the delivery window an access pass is needed. One can buy a pass at the local government offices. This pass is linked to a firm name or license plate number and can only be used once per 30 minutes to enter the restricted area. Road signs at the edge of the city center combined with warning signs next to the bollards inform drivers about the access restriction scheme.

This 4-hour delivery window is impacting business in this area. Deliveries in this restricted area to shops, restaurants, offices and bars have to take place within these opening times. Hotels are however located outside this restricted area and are not influenced by this delivery window (Rasch, 2006).

To minimize the burden of this delivery window dispensation to the restricted area, two types of operators are allowed to enter outside the delivery window (Rasch, 2006):

- The first concerns operators with vehicles with more than 15 deliveries on the same day in the city center. This group can get a (maximum) extension of the delivery window of three hours. With this regulation the municipality stimulates freight bundling and hopes to prevent commercial shopping chains closing their shops in the city center.
- The second concerns deliveries to the catering industry. Deliveries to restaurants and bars are allowed outside the delivery windows, as they are generally closed during the delivery windows. These deliveries must take place via roads outside the shopping area in order that visitors and inhabitants are not hindered by these dispensations.

Beside the dispensation rules, exemptions of the 4-hour delivery window can be obtained by inhabitants (and their guests) and employees of offices (Rasch, 2006):

- Inhabitants can obtain access at all times in the restricted area if they obtain an access license. The price of this license equals the administrative costs for making this license (currently 23,90 €);
- Guests/visitors of the offices in the inner city can obtain a day access pass (cost 7 €); and
- Employees of the offices are able to obtain permanent access (cost also 23,90 €).

3.4.1.3 Conclusions

The first results of this relatively new scheme are promising. In the old situation the city center was closed for all traffic between 6 pm and 7 am. On a normal day about 600 vehicles travelled through the inner city. With the introduction of the bollard system this amount was reduced by 40% (Rasch, 2006).

Outside the delivery window the city center of Enschede is almost free from vehicles. This creates a more pleasant environment for visitors of the city and the shopping area. This stimulates the attractiveness of the inner city for business activities and visitors.

Access restriction only works combined with effective enforcement. In the case of Enschede a lack of enforcement created a situation where passes were illegally used by unauthorized passenger cars outside the delivery windows.

3.4.2 NEW REGULATION OF CITY ACCESS IN MONTPELLIER (FRANCE)

3.4.2.1 BACKGROUND AND OBJECTIVES

Montpellier is a city that had a dynamic development in the tertiary sector and where conflicts arouse due to the urban sprawl, essentially between activities in the center and in the suburbs.

Transport companies hold that the previous regulation was too strict and difficult to apply. In the pedestrian zone, they saw a major divergence between regulation and their application, notably because of non-adapted time-windows and too strict weight limits. Indeed, they need to use more vehicles on the morning hours to deliver on time. That situation encourages operators to use more and more small vehicles which generate congestion, including further environmental impacts. To top it off, delivering bays are not frequent, unsuitable sized and often occupied by parked cars (Bouhlel, 2006).

Because of this situation local authority was asked for an improved road traffic management and a more suitable time-window scheme for deliveries. The project of a new regulation was a wish of both transport operators and the municipality.

The objective of the project's first step is to promote the use of electric vehicles in the pedestrian zone. Secondly, the municipality plans to extend that rule to GNV (Natural Gas) vehicles and other fuel-alternative powered vehicles. The inner-city is a large pedestrian zone (25 km2) with neither car-parks nor delivering bays. Therefore, the city has to find a compromise between pedestrian flows (peak at noon) and the deliveries. An urban distribution center had to be built from where all vehicles would operate.

Further objectives also were to find better solutions for harmonized freight deliveries and the enhancement of the quality of life of the city's inhabitants (Bouhlel, 2006).

3.4.2.2 IMPLEMENTATION

In May 2006, the city of Montpellier voted for a new freight access regulation for the city-center. For the first time a local regulation – of a city of more than 100.000 inhabitants - stipulates that access to the pedestrian zone is not allowed for non-electric vehicles during two time periods per day. All kinds of vehicles can access the pedestrian zone from 4 am to 9 am, after 9 am the access is restricted. Deliverymen have to insert an access-ticket into the pay and display machine which is situated at the entrance of the pedestrian zone. There is no weight or size limit for this period (Bouhlel, 2006).

After this time window, from 9 am to 12 am and from 2 pm to 7 pm., only electric commercial vehicles (length < 3.50m and width < 1.60m) are allowed to access the area. Loading and unloading activities are often performed in the afternoon. Only electric vehicles can operate during this time, which creates a specific market for operators (Bouhlel, 2006).

The technology used is quite basic. Pay and display machines with an intercom are located at the main entrances of the pedestrian areas and deliverymen have to take a ticket to that points, facilitating control by the municipal police. No specific enforcement staff is planned, but the municipality wants to improve communication and increase police agents' awareness of urban freight to improve enforcement (Bouhlel, 2006).

3.4.2.3 *CONCLUSIONS*

One of the main conclusions of that project is that cities more and more integrate urban freight in their environmental policy. They do not only consider it as a transport activity but as an element of the city which influences the quality of life. To create new rules for deliveries offers many advantages (Bouhlel, 2006):

- Benefits for the local environment (reduction of polluting emissions);
- Foster a reduction of subcontracting, as cheaper subcontractors often use old vehicles which emit more polluting emissions;
- Support the development of clean vehicles;
- Offer more attractiveness to the inner-city.

So, benefits are shared between private and public partners because at the same time there is a reduction of congestion and improved facilities to enforce the regulations (Bouhlel, 2006).

With the implementation of a simple measure that consists of a physical restriction to the inner-city with pay and display machines at the main entrances of the pedestrian areas, and specifying two time windows during the day when the deliveries are possible, it was possible to improve the quality of life in the city and reduce the polluting emissions. The transport operators beneficiate with the access to the city center within the stipulated time windows, but need to invest in clean and non-polluting vehicles.

3.4.3 **MANAGEMENT OF PEDESTRIAN ZONES IN MARIBOR (SLOVENIA)**

3.4.3.1 *BACKGROUND AND OBJECTIVES*

The city had a very dense motorized traffic that resulted in a poor safety for pedestrians. There was a lot of public pressure to improve the situations and the inhabitants used to complain about the high levels of traffic in the city zone.

With the objective of improving the safety for pedestrians and the traffic in the city, it was introduced an access restriction for delivery vehicles.

3.4.3.2 *IMPLEMENTATION*

The deliveries are only allowed from Monday to Friday between 6:00 and 9:00 and between 19:00 and 22:00. On Saturdays, Sundays and holidays, the delivery window is open between 13:00 and 15:00. The access is restricted by a physical restriction, and the Municipal Police supervises the area, recording the vehicles violating the rules and imposing appropriate punishment.

Parking is not allowed in the public traffic areas. Stopping at the delivery bay is limited to 15 minutes and a special written certificate has to be kept on board. The maximum weight of vehicles entering the city zone is limited to 3.5 tons. Vehicles exceeding this weight are requested to have a special permit for entering the city zone (Politic, 2006).

Four sink cylinders are used to prevent unauthorized access. The access to the city zone is enabled by a valid card. Such card enables the cylinder to sink and ensures the access. The system is computer aided and provides for a video surveillance. The technology is based on the network, computer and the entrance card. The measures taken included information published in media and provision of help at the entrance. Main problems are related to damages on the sink cylinder (Politic, 2006).

The area, in which the enforcement activities take place, is daily inspected by one person employed with the Municipal Police. Once a month, the Municipal and National Police staff carries out a joint action punishing the individuals violating the rules. The inspection times are random; the officer tends to round the area in irregular times. The inspection covers the whole area of the enforcement activities. The enforcement activities remain the same during the whole year.

Statistical information:

- Number of checks: 1 per day;
- From 1 January to 31 December 2005, there were 1 002 violations recorded;
- Penalty rates: the fee for wrong parking amounts to 20,000 Slovenian tolars (SIT) (approx. EUR 83.5), and the fee for driving without a special permit accounts for SIT 40,000 SIT (approx. EUR 167), respectively.

The entrance fees to this area are as follows (Politic, 2006):

Table 3.1 - Entrance fees of the restricted area

Entrance fees	EUR
Daily entrance fee: vehicles up to 3,5 t (perishable goods)	350
Daily entrance fee: vehicles exceeding 3,5 t	210
Daily entrance fee: personal cars	5
Daily entrance fee: vehicles up to 3,5 t (perishable goods)	50
FINE (by a commenced hour exceeding permitted 40 minutes)	10

The costs of technology amount to approximately SIT 20 Million (approx. 83 500 €) (Politic, 2006).

3.4.3.3 Conclusions

Taking into account the costs and benefits of this measure during only the year of 2005, and assuming the 1 002 violations would be only with the lower value (83.5 EUR), the total benefits would be 83 667 € and the total costs would be 83 500 €. We can conclude that this measure would have a positive outcome already in this first year.

The sink cylinders contributed to a decreased traffic volume in the city zone, which resulted in a higher safety for pedestrians. There was also a decrease of congestion due to the four entrance/exit gates, and a decrease of overall traffic due to limitation of exit/entrance to the specific gates.

Since the technology works well, the authorities planned to use it in the future (Politic, 2006).

3.4.4 CONCLUSION

The most common measures regarding access restrictions are related to scheduling the access to urban areas that have high demand of deliveries (e.g. the city centre), and there is the need of a good enforcement to reach the desired improvements of the CL of the city. Usually, the municipal authorities control the access of the vehicles with the support of physical restrictions combined with access cards/passes (examples of Enschede and Maribor), but with the evolving environmental awareness and the need to have a sustainable city it is becoming more common to create positive discriminations in favour of electric or greener vehicles, as it is illustrated in the example of Montpellier.

3.5 TRAFFIC MANAGEMENT

Examples like the Intelligent Transport Systems, introduction of delivery lanes or road pricing are included in the category of *traffic management*.

The three examples presented below comprise a system that monitors and enforces the access restrictions, and an automatic number plate recognition system that were implemented in Ravenna; the promotion of dialogue between all relevant stakeholders in order to design the best measures that would make freight activity more efficient in the city of Aalborg; and finally, in Barcelona, it were piloted a combined-use lane and special permits for delivery vehicles to enter a specific pedestrian zone.

3.5.1 TRAFFIC CONTROLLER AND MANAGEMENT SYSTEM IN RAVENNA (ITALY)

The Ravenna municipality area, the second widest in Italy with 655 km2, has 146.000 inhabitants, two thirds of witch concentrated in the city proper. Moreover, Ravenna has one of the highest car/inhabitant ratio (0,65) (START, 2009).

3.5.1.1 BACKGROUND AND OBJECTIVES

The political orientation towards urban goods delivery complies with the broader vision of a city that strives to control, and if possible reduce, air pollution and energy consumption. From 2002 and onwards, urban goods delivery has been an important issue on the local agenda in Ravenna. The city center has a Limited Traffic Zone that includes most of the historical city center and has time zones for restriction of traffic and loading and unloading operations.

The general objectives for the Municipality of Ravenna when it comes to urban goods delivery are the reduction of vans/trucks during the time windows most preferred by tourists, the reduction of illegal parking by loading/unloading vehicles and stimulation of a more efficient urban delivery system by increasing load factors and the usage of cleaner vehicles (Sundell, Perslow, & Vennersten, 2009).

3.5.1.2 IMPLEMENTATION

From 2006 until 2009 the Ravenna city entered the European project with the acronym START, which stands for “Short Term Actions to Reorganize Transport of goods”. During this period, the access and parking regulations in the city center has been formulated in a few new important restrictions that were previously divided into a large number of rules scattered in several acts. The underpinning element of the restrictions is that they are now applied to freight vehicles.

The access restrictions are controlled through a Control Center which has been implemented outside of the START project. In parallel to START, the Municipality of Ravenna has implemented an ITS solution called “Traffic controller and management system” - TCMS. One of the main functions of the TCMS is to monitor and enforce the access restrictions and an automatic number plate recognition system has been fully installed. In every monitoring-point there is a digital camera and a local processing unit, equipped with Automatic Number Plate Recognition (ANPR) software. The software reads the number plate and compares it with the list of authorized vehicles (white list). If a match is found, the image is discharged, if not the image is sent to the control center for a fine (Sundell et al., 2009).

3.5.1.3 EVALUATION

The choice in START was for a lean evaluation exercise based upon a small but homogeneous set of indicators used to compare the quantitative/qualitative impacts of the measures with the targets established prior to implementation.

To evaluate the measure of access restrictions in Ravenna were used the following indicators (START, 2009):

- Environment: CO2 emission, NOx emission, PM10 emission.
- Transport: Vehicle km in demo area, Number of trips in demo area.
- Social/Behavioural: User acceptance in demo area, Number of organisations reached by the dissemination activities.

3.5.1.4 CONCLUSIONS

The ANPR system has been fully working since July 2007. The new access regulation was approved by the City Council while the new “General Urban Traffic Plan” was developed during START, including regulations for "Access and park in City Center" (which differentiate entry rules by vehicle emissions, simplify and rationalize the system of entry permission, extends the LTZ and the park-pricing zone, controls and enforces entries in the historical center).

The Control Center is another result of START, with a newly coordinated management of the different traffic technologies of the Municipality. This is result in an improve cost-efficiency due to the fact that fewer human resources (namely the police) are required for enforcement (START, 2009).

With the implementation of the ANPR system the control and enforcement of the new access regulations is done without a physical restriction and with fewer human resources, thus simplifying the entrance to the city center (no need to wait for the retraction of the physical restriction) and improving the cost-efficiency of the enforcement.

3.5.2 CITY-GOODS DELIVERY CO-OPERATION IN AALBORG (DENMARK)

3.5.2.1 BACKGROUND AND OBJECTIVES

The Danish Ministry of Transport supported the “Sustainable Citylogistic Solutions”-project, a tri-city co-operation between Copenhagen, Aarhus and Aalborg. This project had the objective of improving goods distribution in urban areas with the implementation of new ideas for city logistic solutions based on local conditions, in order to reduce the negative environmental effects caused by freight distribution.

The objectives that were expected to be achieved in Aalborg were: on time deliveries, more efficient deliveries, improved working conditions for freight distributors, and reduced numbers of freight vehicles in the city center (Mikkelsen, 2012).

3.5.2.2 IMPLEMENTATION

The trial in Aalborg started in 2001 and ended in 2003, and was based on voluntary subscription: all stakeholders of the freight transport supply chain engaged in dialogue to define the measures and the framework of the project in order to make freight activity more efficient in the city center (e.g. freight distributors, the commercial operators, retailers, local authorities and law enforcement agencies). The target area was the well-defined pedestrian area in Aalborg (Mikkelsen, 2012).

The involved parties defined a set of measures that included:

- Two persons in each vehicle: with two persons the delivery process was faster, but the second person was not necessarily from the same freight company, which required a strong cooperation between the distributors.
- “One shop” principal: one shop was defined as the “drop zone” for other shops nearby. This measure prevented unnecessary freight trips to shops that opened late.
- Change of driving direction in the pedestrian area: for a better organization of the freight traffic flow in the target area.
- Creation of a consignment note among the distributors: this meant that freight companies could exchange or hand over parcels, without extra costs to the users, if one of them had another delivery in the pedestrian area, which would also prevent unnecessary freight trips.

It was needed a strong involvement of the City of Aalborg and the Aalborg Police in order to make these measures a success.

3.5.2.3 CONCLUSIONS

The trial was based on voluntary participation, which led to the creation of specific measures by the main actors of the freight transport supply chain of the city. The co-operation that was needed to ensure the success of the measures resulted in highly motivated participants.

The main results of the trial were: an average reduction of 5 minutes in activity duration in the city center; better working conditions for the drivers; with the reduced time duration of freight activity there were visual and environmental improvements for all stakeholders in the area; and the number of deliveries on-time to the shopkeepers was raised up.

Finally, the most important conclusion is about transferability. The measures that were implemented in the trial of Aalborg can be transferred to other cities that need to improve the logistics of freight distribution.

3.5.3 STREET MANAGEMENT IMPROVEMENTS FOR LOADING/UNLOADING ENFORCEMENT (SMILE) IN BARCELONA (SPAIN)

The SMILE project implemented junction measures (in the *Eixample* District) and piloted a combined-use lane along *Balmes* Street (*Sant Gervasi* District). Both were successful in improving the availability of curbside space for goods delivery access, and this has improved the general circulation of road traffic (Barcelona City Council, 2000).

3.5.3.1 BACKGROUND AND OBJECTIVES

Goods distribution in cities is widely recognized as vital for achieving and maintaining an efficient and strong economic base. However, it is typical to find goods vehicles inadequately parked for carrying out loading/unloading activities and this also disrupts the general circulation of traffic (Barcelona City Council, 2000).

The Municipality of Barcelona initiated this project in order to control the use of private vehicles, which would make deliveries of goods easier. To address the problems of urban freight movements in the city it was considered that the management of curbside access with efficient enforcement would be a powerful measure. The main objective was "*to increase the quality of life in the inner-city areas*" (Abel & Karrer, 2006).

Here are the numbers of the situation before the SMILE project:

- Some 25 000 vehicles realize approx. 100 000 loading/unloading operations each day in Barcelona.
- 4 000 curbside spaces are required to accommodate the needs of goods delivery vehicles.
- Different measures need to be applied according to different typologies (area, street - in hierarchical design).
- Urban development planning norms should be modified to require delivery bays to be provided in new constructions of >400 square meters.
- Pilot regulatory measures require efficient, automated enforcement.
- Telematics techniques should be employed to optimize operations.

3.5.3.2 IMPLEMENTATION

There were defined new traffic regulations at junctions, which included:

- 700 Zones reserved for loading/unloading only from 08:00 until 14:00 (or 20:00) within the city center.
- Maximum stay period: 30 minutes.

One avenue had a combined-use lane along 1800 meters with installations that reserved the between-peak hours for goods deliveries and in peak-hour had clearways. Variable Messaging Signs (VMS) were installed along the street to clarify who is allowed to use the street according to the time of day.

Special zones for pedestrians where access was only possible with a special permission: These zones (5 zones which are centrally controlled) had only a few entrances (50 gates are installed city-wide) with barriers which could be entered by use of a special key-card (8 000 resident cards were issued; further cards were available for delivery vehicles). For delivery vehicles access was only allowed during defined time windows. In order to avoid abuse the entrances were monitored by camera.

3.5.3.3 CONCLUSIONS

Before and after observations were carried out to determine the effect of the improved signing and enforcement of traffic regulations. Based upon a comparison of observations at four junctions (of the 700 where measures were implemented) the following results were achieved (Barcelona City Council, 2000):

- The level of space occupancy reduced from 81% to 57%, with an average of 25,9 minutes per hour per space available in the After situation compared with only 11,6 minutes per hour per space available in the Before situation;
- The increase in space availability is partly due to less parking actions occurring in the After situation;
- But the larger part of the reduction is attributable to the shorter stays of vehicles that park in the zone. The average length of stay of vehicles observed to carry out un/loading operations decreases from 19,54 minutes to 17,89 minutes.

In the special lane, the measures have resulted in the elimination of illegal parking by residents. During the hours that the lane is dedicated to loading/unloading the goods delivery vehicles can always find a place to park - double parking no longer occurs. As a result of the improved discipline in lane usage, junction capacity along *Balmes* is optimized during peak hours and the levels of saturation have been reduced with a corresponding improvement in traffic circulation. The VMS signals are highly visible and this has contributed to the overall success of the scheme (Barcelona City Council, 2000).

In the SMILE project, the Municipality has successfully designed and implemented measures that have improved the availability of curbside space for goods vehicle loading/unloading. It can be seen that the result of the increased enforcement has been an increase in curbside availability for goods deliveries loading/unloading.

3.5.4 CONCLUSION

In conclusion, the measures that are included in this category are often combined with the implementation of initiatives from the other categories. This may be due to the need to control and enforce the desired changes in the behaviour defined by the authorities. The first example showed that a Control Centre is supported by an automatic plate recognition system with the aim of ensuring that the necessary enforcement activities take place. In the example of the combined-use lane there was also the need to use Variable Message Signs, because there was the need to inform the drivers of the new schedule for the use of that lane. The example from Denmark is different, because the measures that influenced a change in traffic were a result of a dialogue between all relevant stakeholders, which is a good starting point to reach good results when there is a need to re-arrange the traffic and driving behaviour in specific urban zones.

3.6 ENFORCEMENT AND PROMOTION

These measures are related to improvements of the enforcement of parking. Below it will be presented four examples of measures that fit in this group.

In the Spanish city of Barcelona it were implemented two measures to improve the deliveries in a neighborhood, one was about web info and targeted enforcement and the other was about special kerbside regulations. Also in Spain, but in Bilbao, it was implemented a system for booking the loading/unloading bays which monitors, with the help of technology, those parking bays. In the Serbian city of Subotica, the public authorities implemented a system that manages and controls parking payments and services, with the possibility to pay using SMS. Finally, the city of Treviso, in Italy, created a whole new parking system in the historical center that uses several technological solutions.

3.6.1 MIRACLES PROJECT IN BARCELONA (SPAIN)

Within the project MIRACLES, in 2004, the city of Barcelona implemented two measures: Loading/Unloading Active Guide (web info and targeted enforcement), and PICT Trials (special kerbside regulations) (Hayes et al., 2006).

3.6.1.1 BACKGROUND AND OBJECTIVES

Barcelona Municipality had realized city-wide surveys of samples of commercial premises and operators which quantified more than 47 000 commercial premises generating some 100 000 un/loading operations per day. Based on this, in the period 1998-2002 the total number of reserved spaces for goods deliveries was increased to 8 432 spaces.

Some 22% of these spaces are concentrated in the *Eixample* district which has a grid network of streets with junctions every 100 meters. Reserved spaces are located within the junctions with a capacity for 4 or 5 vehicles per reserved space, operating from 8:00 to 20:00. The number of space-hours available is designed to meet the overall measured demand derived by the city-wide survey. A cardboard disc is provided to those vehicles authorized to use the reserved spaces, and this disc is used to control/enforce the maximum stay limit of 30 minutes (Hayes et al., 2006).

The objectives were focused on:

1. Improving Municipal management of vehicle circulation on the main and local road networks.
2. Reducing delivery times and costs.

3. Developing mechanisms to self-finance the successful scheme elements.

3.6.1.2 IMPLEMENTATION

The first measure (Active Guide), covering a pilot area with 230 reserved spaces, consisted of exchanging information via the web between 8 supermarket operators + 3 distribution companies with the Municipality. The Municipality would be responsible for the aggregation of the information and for making it available to the registered operators to enable them to plan to avoid hot spots (times and locations of congested delivery). The information would also be used by the municipal police to prioritize enforcement actions to those hot spots.

The second measure (PICT trials) consisted of temporary short-term (2 to 4 hours, much smaller than previous regulations) loading/unloading spaces with special regulations restricting access to the kerbside directly in front of the supermarket only to vehicles of the 3 participating operators. This measure was only allowed when the supermarkets were located at more than 25 meters from the existing reserved spaces.

The vehicles participating in these two measures were identified with the same cardboard disc.

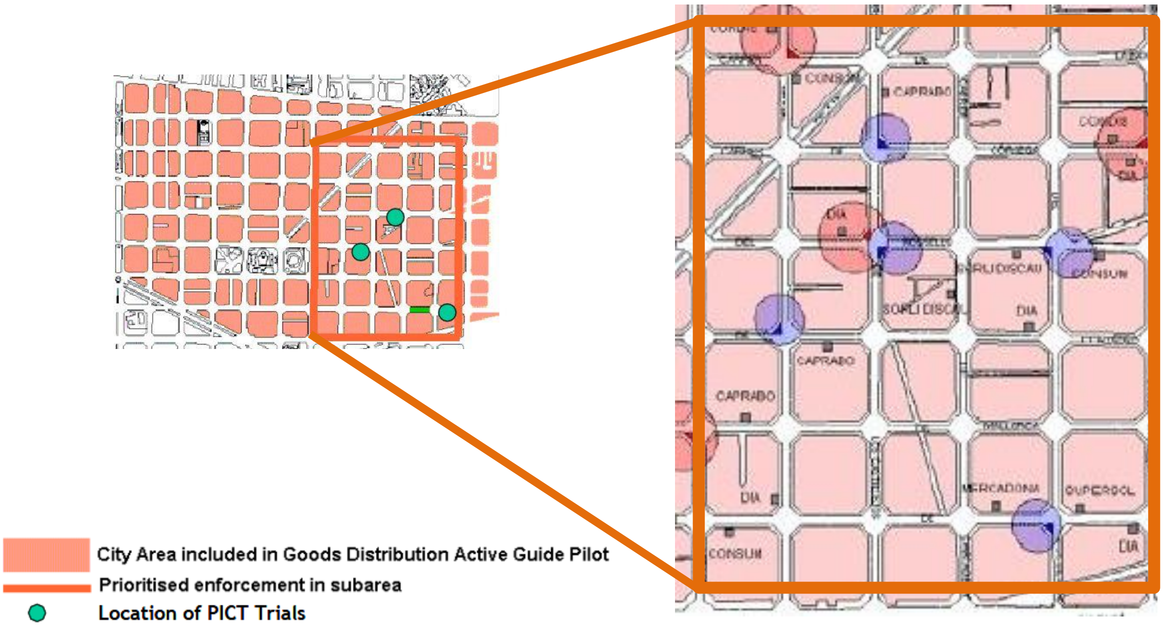


Figure 3.4 - Map of the pilot area in Barcelona. Source: (Hayes et al., 2006)

In the figure above we can see a map of the pilot area in Barcelona, with the location of PICT Trials, on the left; and the zone that had prioritized enforcement, on the right, with the hot spots identified (pink: incidence reported by more than one operator; blue: incidence reported by one operator).

3.6.1.3 CONCLUSIONS

The ratio of demand to supply of deliveries spaces above 85% typically result in degraded levels of service, and in the pilot area of the Active Guide, the observations from circuit surveys quantified the demand/supply ratio to be 112%. During the period of the trial it was found that operators encountered difficulties on 67% of the deliveries.

Information received about operators' schedules was aggregated to identify locations/times where unloading actions are concentrated (i.e. the "hot spots" for enforcement). It was demonstrated that this information can be published to encourage operators to voluntarily re-schedule deliveries at congested locations to less-busy times of day, but such behaviour was not observed during the trial, and the concentration of early-morning deliveries for this (food distribution) sector suggest that operators are most interested in more and better located spaces.

One of the results is the way that monitoring of reported incidents can identify those locations where problems are concentrated, and also measure temporal changes following targeted enforcement.

Another result it that operators' reports show deliveries to be concentrated in the early morning and more than a third of incidence reporting occurs in this time period.

During the trial, enforcement was targeted at two zones with more early deliveries (zones 3 and 19) and another without (zone 11), where particularly high levels of problems had been reported. As a result of the enforcement an average reduction in problem-reporting of 18, 6% was achieved at these location/time periods:

Table 3.1 - Active Guide: results of targeted enforcement (Hayes et al., 2006)

		% of deliveries reporting problems with unloading	
Nº of operators	Zone ref.	Before	After
2	3	85	67
3	11	63	40
2	19	82	67

As for the PICT trials, the estimates of delivery times that have been computed indicate that this measure achieves significant reductions in times for operators compared to the normal city situations, although the measurements of delivery operations and times were realized to different degrees at the different sites. It is possible to evaluate the performance of the PICT locations on the Table 3.2 (Hayes *et al.*, 2006, pg. 40).

Table 3.2 - Comparison of supermarket deliveries: PICT versus usual U/L zone (Hayes *et al.*, 2006, pg. 40)

	Type of unloading	Distance (m)	Unloading Time (min)	Total time (min)	Trips (nº)	Persons (nº)	Goods Volume (m3)	Affected Pedestrians (nº)	Time/Volume Ratio
U/L Zone	Pallet	30	13,3	27,0	5	2	15	13,7	0,9
PICT Trials	Trolley	0	6,5	8	2	2	11	8	0,7

The indicators used to evaluate these two measures are presented below.

Table 3.3 - Summary of indicator for the two measures (Hayes et al., 2006)

Indicator	Units	Baseline	After Miracles	Measure
Econ. 2	Operating costs: Unloading/delivery times	Only 18% of deliveries achieved from reserved spaces within 25m, with no need to cross street	PICT results show unloading time can be halved, overall delivery time reduced by two-thirds if delivery is made from spaces in front of supermarket outlets	Active Guide / PICT pilot
Soc. 14	Acceptance operators (responses from 11 participants in Active Guide, 0 to 5 scale)	n.a.	1) 3.3 2) 4.0	1) Active Guide 2) PICT spaces
Tran. 28.c	Nº of transport operators registered	n.a.	11	Active Guide
Tran. 28.d	Nº of transactions realized	0	1772	Active Guide

The web can serve as an effective channel to register times and locations where operators' delivery problems are most severe. To ensure strong operator participation in the short-term, authorities are advised to use this new information to carry out targeted enforcement of the "hot spots"; this can reduce the level of problem-reporting by operators significantly (around 20% in the case of the Barcelona MIRACLES trial). In order to address "structural problems" regarding the improved location of unloading spaces, medium-term actions such as the PICT trials can be incorporated in the collective initiative to good effect. The operators participating in the PICT trials were satisfied with the outcome (e.g.: elimination of a 30 meter distance reduced overall delivery times from 27 to 8 minutes), and enforcement agents did not encounter an increase in illegal parking.

3.6.2 DELIVERY SPACE BOOKING IN BILBAO (SPAIN)

3.6.2.1 BACKGROUND AND OBJECTIVES

The Delivery Space Booking application for Bilbao is based on the work done in the European project Cooperative Vehicle-Infrastructure System, CVIS. The goal of this application is to support the driver, fleet manager and road operator (including parking zone operator) in the booking, monitoring and management of the urban parking zones for freight driver activities (Tevell et al., 2009).

The system allows the fleet manager to book in advance an urban parking zone specifying the time of day required, the duration required, the type of vehicle to be used, and possible dangerous goods transported. For the road operator, it describes the possibility to optimize the management of parking zones through better knowledge of the delivery time period and duration in order to (Tevell et al., 2009):

- improve the flow of vehicles;
- reduce all negative impacts due to double lane stops;
- reduce consequent traffic congestion; and
- reduce urban environmental impacts.

3.6.2.2 *IMPLEMENTATION*

The delivery space booking application consists of three subsystems, an in-vehicle application for handling parking zone reservations, a parking zone operator back-office system and a fleet operator back-office system (Tevell et al., 2009).

To reserve parking slots, a fleet manager uses a web-based back-office system connected to the parking operator back-office. During the vehicle trip, the estimated time of arrival is estimated to detect late or early arrival at the parking. At the parking entrance, the vehicle notifies the parking operator back-office which grants or denies the access to the parking area.

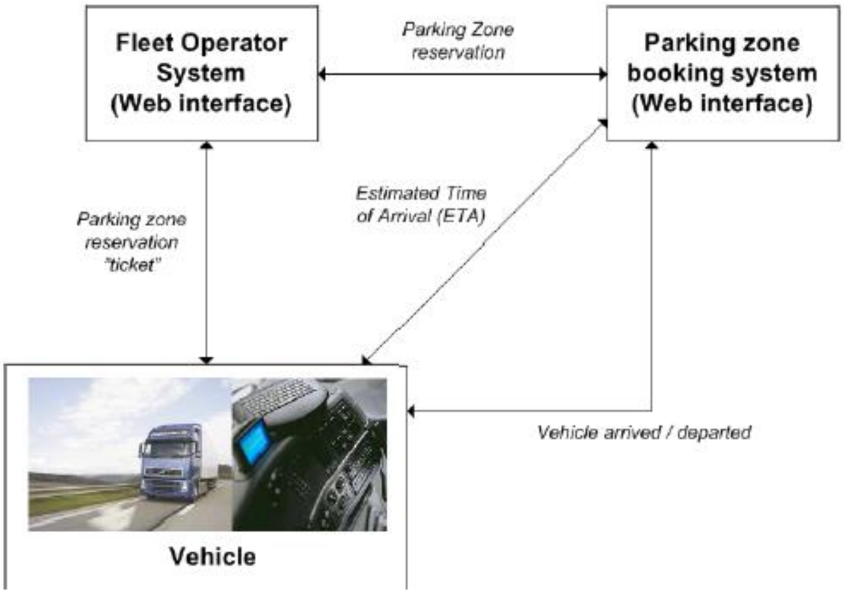


Figure 3.5 - Overview of the Delivery Space Booking application. Source: (Tevell et al., 2009).

The loading/unloading timetable was established from Monday to Friday, from 8:00 a.m. to 7:00 p.m., and the day was organized in 22 loading/unloading slots of 30 minutes. Each truck is able to book as many slots as required in the same day, with the restriction that can never book two consecutive slots (Tevell et al., 2009).

3.6.2.3 *RESULTS*

These are the numbers of the first results (Blanco, 2012):

- 4 Delivery Space Booking areas
- 35 truck companies participating in the project
- 1693 GPS files were recorded:
    - 1601 are considered valid routes
    - 1248 routes have at least one delivery stop around the studied delivery spaces
    - 625 of the stops were made during the reservation time period

Table 3.4 - First results of the Delivery Space Booking in Bilbao (Blanco, 2012)

DSB Areas	Number of baseline stops	Number of pilot stops
General Concha	9	46
Pérez Galdós	30	122
Licenciado Poza	31	102
Santutxu	40	208

The travelled distance to park presented some differences between the expectations and the actual pilot results, and more precisely each delivery bay had a specific behavior. And the variability of this distance decreased during the pilot (Blanco, 2012).

As for the fuel consumption, there was also a different behavior for each delivery bay, and during the pilot it was observed a significant statistical reduction for heavy vehicles (Blanco, 2012).

3.6.2.4 COSTS

The budgets of the costs of implementation of this system in Bilbao are the following:

Table 3.5 - Total budget of the Delivery Space Booking application (Tevell et al., 2009)

Action	Amount
Budget L/U Zones	57.600,00 €
Budget Control Software (back office)	24.200,00 €
Budget Control (Enforcement)	0,00 €
Budget Vehicle (most economical)	300,00 €
TOTAL	82.100,00 €

The budget for L/U zones includes: beacons and civil works (4.000€), signaling and painting (2.000€), management and coding chip cards (1.500€), 3 sensors to identify vehicles (900€), information panels (0€) and city parking toll machine (6.000€). These are the numbers for each delivery zone.

According that there are 4 delivery spaces of the pilot in Bilbao, the total budget for all the L/U zones is 57.600€.

3.6.2.5 CONCLUSIONS

According to the presentation of Blanco on the final event of the project, in the 19th of June 2012, the main conclusions are: the technical performance of the systems was demonstrated during the pilot, whether by the high success and participation in the project or the high implication from the different stakeholders and the participants (Blanco, 2012).

This was an innovative project about ITS applied to the problematic of loading and unloading activities within the cities. And Bilbao even received in April of 2012, the National Award for Best

Project of the Year in the field of Freight Transport for the European project FREILOT. This was a prize awarded by the national association *ITS España*.

3.6.3 SYSTEM SMS4PARKING IN SUBOTICA (SERBIA)

3.6.3.1 BACKGROUND AND OBJECTIVES

The central zone of Subotica is characterized by unregulated parking places, as well as a large number of long-lasting parking situations that complicate the parking problem in the area. In order to deal with that problem, the Public Utility Company "Parking" from Subotica, which is in charge of organizing, charging and controlling the parking services in this town, this company started to use a solution called SMS4PARKING. This ITS solution that was chosen is based on Microsoft technologies, created by Pakom Solution Centre (PSC) from Belgrade, uses mobile communications services and SMS text messages to solve the problem of charging and control of parking in an efficient and comfortable way. With SMS4PARKING the "Parking" company can centrally manage and control parking payments and services, improving the quality of life in Subotica (Radosavljević, 2012).

3.6.3.2 IMPLEMENTATION

This system was implemented in the 1st of June 2006, and is based in 3 different steps:

- Step 1: the car driver sends a SMS with the car registration plate number to a parking code number in order to pay for parking.
- Step 2: The parking centre sends a SMS receipt with the ticket number and all important details (parking zone, validity time, price, etc).
- Step 3: The user receives a SMS from the parking centre warning him that the parking time expires in the next 10 minutes.

With this system the City of Subotica has eased the parking paying system, which is more comfortable for the car users, and also the enforcement of the illegal parking. The SMS4Parking provides very efficient control of parking processes. The parking officers are connected to the back office via PDA or cellular phone, and through Bluetooth technology to a wireless micro printer. They type the car's registration plate number and the system sends back the information within seconds (paid fee and when it will expire, or unpaid fee). In case the parking fee was never paid or it expired, the parking officer prints the fine. This system also informs the car users where the empty parking spaces are and how much capacity there is left, and now there isn't a single street in the city centre where you can't find a free parking space (Radosavljević, 2012).

3.6.3.3 CONCLUSIONS

The benefits of the introduction of this ITS solution are:

- Reduced time of waiting for an available parking place
- Number of parking violations reduced
- Increase of the income from the parking fees, which made possible to invest and further develop this municipal subsystem

- Improved citizen's satisfaction and comfort of living in the central city area
- The system's implementation was very fast, required a minimal investment and the resources invested were very quickly returned
- The system has the ability to be expanded and adapted according to the users' needs

It were registered an average of 3000 SMS text messages sent via SMS4PARKING in Subotica per day, which is equivalent to 60% of the parking service payments, even though using the parking meters or ATMs is cheaper. This fact may be explained because this system informs the user of how much time has left remaining and its ease of accessibility.

3.6.4 THE I-PARK TREVISOSTA SYSTEM IN TREVISO (ITALY)

3.6.4.1 BACKGROUND AND OBJECTIVES

The public transport operator for the city of Treviso, ACTT, wanted to improve the parking system in the city center. In January 2012 was chosen the FL200 system, by Smart Parking Systems, and the "I-PARK – Trevisosta" (a society of ACTT) was created to manage the new parking system in Treviso. This new parking system is based on wireless sensors installed in every parking bay in the historical center, which communicate with the parking meters that, in turn, send real-time data to the park management server. The park management server is connected to Variable Messaging Signs (VMS) that inform the citizens about parking availability in various zones of the city center. This system allows several paying methods, and doesn't require a parking ticket or cardboard disc displayed in the windshield (Bartolo, 2012).

Figure 3.6 - VMS informing in real-time the availability of parking. Source: (Smart Parking Systems: "Intelligent management of the parking area")

3.6.4.2 IMPLEMENTATION

Every parking bay within the city centre is identified with a number. The sensors are positioned below the road surface in line with each parking bay, which communicate to the parking meters the state of presence of vehicles. The parking meters collect all data from the sensors and payments made by users, and send it to a central server. This central server processes all data received and makes it available for the parking administrators and parking officers.


Figure 3.7 - Installation of the wireless sensors. Source: http://www.civitas.eu/sites/default/files/documents/Crosato_Parcheggi_Treviso.pdf

The system is very simple to use: after parking the car, the user has to dial the number of the parking bay that he occupied on the parking meter, and pay for the desired parking period receiving a receipt. The I-Park Trevisosta scheme provides 5 different payment methods: coins, SMS, smartphones, rechargeable cards or time cards. The FL200 system can also recognize whether the vehicle belongs to a resident, and allows different treatments (e.g. no cash or discount, unlimited parking time limit, etc.) (Smart Parking Systems: "Intelligent management of the parking area").

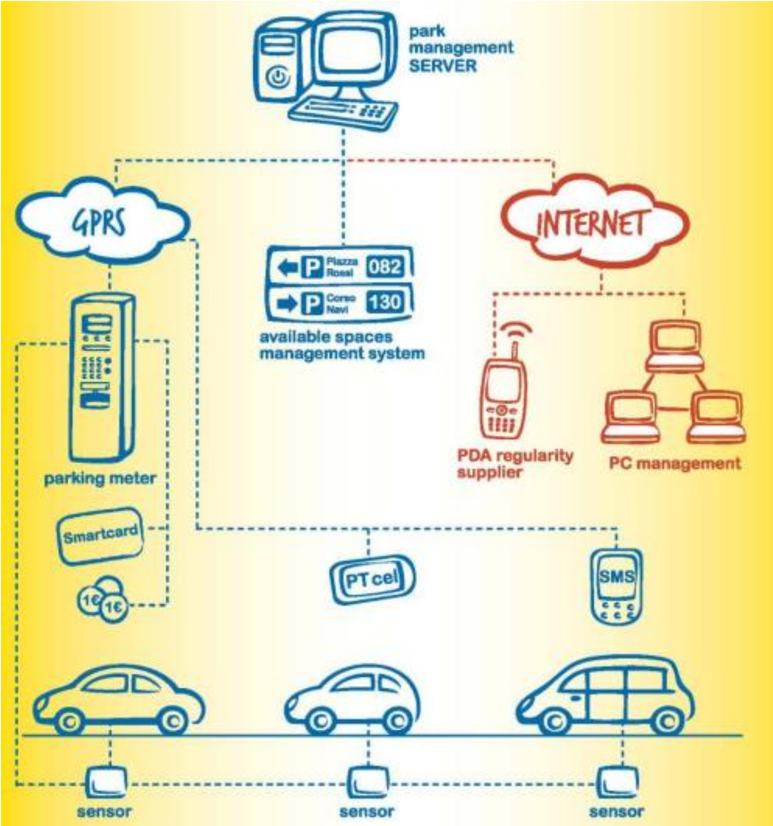


Figure 3.8 - Explanation of how the system works. Source: (Smart Parking Systems, n.d.-a)

According to the specifications given by Smart Parking Systems, the sensors do not require wiring, and have the guarantee that the power will last for 10 years because they have a large capacity battery and the data is transferred using radio frequency that requires very low power (Smart Parking Systems: "S200 Sensor").

The communication between the parking management server and all the other system components is made using proprietary wireless protocols and GPRS.

3.6.4.3 CONCLUSIONS

After the first year of implementation the results were very satisfying. With this new system, the enforcement has become more effective. The parking officers are informed when a violation occurs, which can be a nonpayment situation, the parking time has expired or the maximum time allowed for parking was exceeded. The system informs and notifies the parking officers, through the PDA terminals, allowing them to fine the vehicles that are violating the parking regulation. The efficiency of the whole parking system was increased resulting in an increase of 10% in total revenues (Bartolo, 2012).

There were also benefits regarding the availability of parking bays, since there were no longer non-paying users illegally occupying the parking spaces. The system also had the effect of reducing the use of an underground parking structure for 250 cars, which was indispensable to meet the estimated parking needs of the city, since the parking bays on the ground were no longer over-crowded.

Finally, there was an improvement of the user's satisfaction towards the parking system much due to the improved payment system. With the new system the payment of the parking can be made at any parking meter, or simply by SMS, which enables the parking users to extend their parking time without the need to return to their vehicle (Bartolo, 2012).

3.6.5 CONCLUSION

Generally the measures of this type refer to implementation of technology with the aim of monitoring and controlling the behaviour of the drivers. The main objective is to assure that the laws and regulations are obeyed.

With the advances on wireless communications, the enforcement entities now have several solutions that perform a permanent and reliable monitoring of the CL activities. And the widespread of devices that can be connected through the internet, provides a source of real-time information that can be accessed by a large group of people. The examples of Barcelona, Bilbao and Treviso, presented above, illustrate this idea.

Besides, with the advances in technology it is now possible to think of easier ways for the citizens and deliverymen to pay for the time they park, without the traditional parking ticket or cardboard disc displayed in the windshield, as it was exemplified by presenting the new system created in Subotica.

3.7 CONCLUSIONS OF THE CHAPTER

Various options can be considered by the municipal authorities with the purpose of improving CL. Whether it is a technological solution or a change in the regulations that lead to the desired changes in the drivers and citizens' behaviour, it appears to be very important to include all stakeholders of CL in the planning process. A positive debate between all stakeholders, where they state their needs and preferences, seems to generate higher acceptance rates among them and can provide a solution that satisfies everyone.

The examples presented in this chapter are only a sample of the existing measures of the five categories of CL measures, but they represent the most common initiatives.

All five categories presented provide important and useful measures to improve the efficiency of CL activities in urban areas, but according to the characteristics of the city some measures should be more appropriate than others. Therefore, it relies on the municipal authorities (or the relevant entities that regulate the CL activities) to choose the measures that better adapt to the dynamics of the city where they want to implement, in order to provide the best results possible.

There is the need to keep pace with the technological advances to allow using these in the planning of new logistic solutions. With the internet as a source of real-time information that can be accessed by almost everyone with a portable device, and the wireless communications devices that now exist, it is possible to design a system that monitors and controls several activities that are occurring at the same time in a whole city. These new systems can provide great efficiency gains of the monitoring and enforcement activities. Since they are less reliable on human resources, they make the process more automatic and cheaper in the long-haul.

4 ITS PROJECT EVALUATION

4.1 INTELLIGENT TRANSPORT SYSTEMS

This chapter pretends to give an overview of the technological solutions that can be used in the CL measures. It is given a definition of Intelligent Transport Systems, followed by a classification of the varying scope of technologies that are available nowadays, and finally it is presented a list of the most relevant options that can be used in the area of CL.

4.1.1 DEFINITION

The term “Intelligent Transport Systems” (ITS) speaks for itself. ITS stands for intelligent systems that improve the efficiency, security and operational conditions of transport networks. This concept refers to the innovations in transportation that use advanced electronics and information technologies to improve the performance of highways, vehicles and public transport systems. For Gurínová, *“ITS refers to a variety of tools, such as traffic engineering concepts, software, hardware and communications technologies, that can be applied in an integrated fashion to the transportation system to improve its efficiency and safety”* (Gurínová, 2005, p. 1). Maccubbin, Staples, & Kabir highlight that ITS improve transportation safety and mobility, and enhance productivity through the use of advanced communication sensors, and information processing technologies encompassing a broad range of wireless communications-based information and electronics (Maccubbin, Staples, & Kabir, 2008).

Following these definitions of ITS, we can conclude that the ITS system is based on 3 key elements: the driver, the infrastructure and the vehicle, which interact between them to achieve the objectives purposed (Fonseca, 2011). And this idea is based on Benouar because he expressed that *“ITS is a system of systems which includes the driver (behavioral characteristics, human machine interface, etc.), the vehicle (personal, transit, etc.) and the infrastructure”* (Benouar, 2002). The Figure 4.1 illustrates this idea:

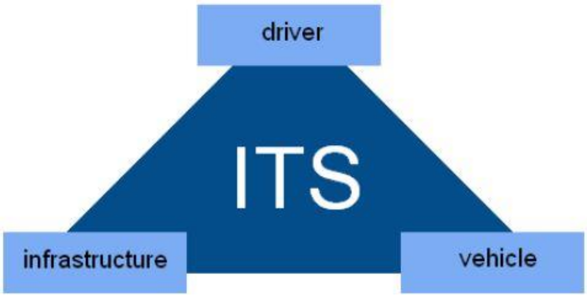


Figure 4.1 - Relation between the three main entities of ITS. Source: (Fonseca 2011)

4.1.2 TYPES OF ITS

There are many different types of ITS, and they vary according to the purpose and the transportation system that we want to improve. It can be a simple traffic sign, a GPS tracker, a complex program that monitors and regulates the whole network, a parking meter, among many other examples.

The United States Department of Transportation suggested in 2008 a classification of ITS systems (Maccubbin et al., 2008), but it lacked three categories relevant to the presented work: parking; access restrictions; and wireless communications. The division was adapted by the author and is presented below:

Table 4.1 - Division of ITS systems

Intelligent Infrastructure	Roadways	Arterial Management
		Freeway management
		Crash prevention and safety
		Road weather management
		Roadway operations and maintenance
	Public Transport	Public transport management
		En-Route Transit Information
		Personalized Public Transit
		Public Traffic Security
	Management and Operations	Transportation management centers
		Traffic incident management
		Emergency management
		Electronic payment and pricing
		Traveler information
		Information management
	Freight	Commercial vehicle operation
		Intermodal freight
		Parking
		Access restrictions
		Wireless Communications
Intelligent Vehicles	Vehicles	Collision avoidance
		Driver assistance
		Collision notification

Source: Adapted from (Fonseca, 2011)

As mentioned before, great efficiency gains can be achieved with the use of technology incorporated in the enforcement activities, especially where technology can make the process more automatic.

The purpose of this dissertation is to study the process of monitoring and enforcement of CL activities, which the use of technology can help to make the process easier and not so dependent on human resources. In order to do so (and regarding the types of ITS stated on Table 4.1) the most important category of ITS is the "**Intelligent Infrastructure – Freight**". However, it is possible to use ITS from other categories that fit the purpose of monitoring/enforcing CL activities. A list of the most common ITS solutions used in CL measures is presented below (Fonseca, 2011):

- **Roadways - Arterial Management**: Variable Messaging Signs (VMS); and Automatic Number Plate Recognition (ANPR).
- **Management and Operations - Transportation Management Centers**: Traffic Controller and Management System (TCMS).

- **Management and Operations – Electronic payment and pricing**: Electronic payment cards.
- **Freight – Commercial vehicle operation**: Automatic Vehicle Identification; Automatic Vehicle Classification; Automatic Vehicle Location; and Board Computers.
- **Freight – Parking**: Parking Toll Machine; Induction Loop; and Floor Sensor.
- **Freight – Access restrictions**: Retractable Bollards; Sink Cylinders; Traffic Light; and Pay and Display Machines with an Intercom.
- **Freight – Wireless communications**: in-vehicle Radio-Frequency Identification (RFID); and Mobile Phones (with internet).

The Intelligent Transport Systems are the technological tools that can be used in the CL measures. All these different types of ITS can be used to overcome (or mitigate) the current challenges faced by the CL activities, however there is the need to choose the ITS solution that better adapts to the problem that we want to solve.

4.2 PRIVATE VERSUS PUBLIC SECTOR INVESTMENT APPRAISAL

In most European countries, transport infrastructures are mainly public owned, consequently the majority of investments in this area tend to be oriented in achieving a variety of social objectives, which is the opposite objective of private investment. These public investment projects need the appropriate methods of evaluation to guide the choice of the better alternative and the allocation of scarce resources. According to Bristow & Nellthorp (Bristow & Nellthorp, 2000) the social objectives of public investment appraisal commonly include:

- Economic efficiency, which is measured using a social cost-benefit analysis;
- Diminishing environmental damage, which is measured by the results of an environmental impact assessment; and
- Other examples related to equity, accessibility, long-term cash-flow or achievement of regional development policies.

As for the privately funded projects, they also need to produce benefits to their developers but in terms of increased sales revenue or company prestige, among others. The private company point of view allows a financial Cost-Benefit Analysis (CBA) (which is a special case of socio-economic CBA) with the main focus on the single stakeholder that is the investor. The private sector has a consistent rational behavior of making decisions for profit-maximizing, but for the public sector the decision is rational if it’s made with the objective of maximizing social welfare.

4.3 EVALUATING ITS PROJECTS

The investment in ITS needs to be made on objective grounds that are credible to the decision-maker, i.e., it has to be justified based on balanced information (Lee Jr., 2004). According to Gillen and Levinson (Gillen and Levinson, 2004), there are two main reasons behind the analysis of ITS projects. The first is the need to obtain the highest benefits from the implementation of ITS projects in order to justify the investment. The planners and policy-makers need to analyze and compare competing projects by understanding the differences of the benefits that each project generates. Secondly, each project will have both positive and negative impacts, and the decision-maker has to ensure the proper design that will maximize the positive and minimize the negative.

ITS projects need to be appraised by comparing its virtues and deficiencies, in order to determine the consequences of the project and to handle this knowledge. The best project is the one where the virtues compensate for the deficiencies, i.e., it has the greatest so-called net gain. The objective is to find a methodology that can decipher both quantitative and qualitative information in a way that makes it comparable and to find a rational and trustworthy method to compare that information (Salling and Leleur, 2011).

4.3.1 GUIDELINES ON HOW TO ASSESS ITS IMPLEMENTATION

Nowadays it is common to elaborate a framework on how to estimate which ITS investments are socially worthwhile and draw up guidelines for the impact assessments of ITS projects (Kulmala *et al.*, 2002; Lee Jr., 2004). In the USA the United States Department of Transportation issued guidelines for the evaluation of ITS projects (ITS Joint Program Office, n.d.-b); and in Finland, the Ministry of Transport and Communications has drawn guidelines for the evaluation of ITS projects (Kulmala *et al.*, 2002). These examples of evaluation framework are explained below.

4.3.1.1 RECOMMENDED EVALUATION PROCESS IN USA

In the United States of America it was created the "National ITS Program" that has, among others, the objective of ITS Evaluation sponsorship where *"in-depth studies are conducted concerning modeling and simulation of the impact of ITS deployments, estimating the costs and benefits of ITS technologies, determining user acceptance of ITS products and services, and investigating institutional and policy issues related to ITS"* (ITS Joint Program Office, n.d.-a).

The ITS Joint Program Office recommends employing the following six-step process for ITS project evaluation. This process has been employed successfully by many ITS projects in the past (ITS Joint Program Office, pg. 2).

Step 1: Form the Evaluation Team – The team consists of one member of each project partners and stakeholders, one being designated by the program manager, the team leader.

Step 2: Develop the Evaluation Strategy – Includes a description of the project to be evaluated and identifies the key stakeholders committed to the success of the project. It also relates the purpose of the project to the overall ITS goal areas (safety, mobility, efficiency, productivity, energy and the environment, and customer satisfaction).

Step 3: Develop the Evaluation Plan – In this step, the evaluation approach should be refined by formulating hypotheses.

Step 4: Develop one or More Test Plans – Each test identified in the previous step will need a Test Plan, and this Test Plan lays out all of the details regarding how the test will be conducted, and identifies the number of evaluation personnel, equipment, supplies, procedures, schedule, and resources required to complete the test.

Step 5: Collect and Analyze Data and Information – Consists of the implementation of each Test Plan.

Step 6: Prepare the Final Report – The final step in the evaluation process is to document evaluation strategy, plans, results, conclusions, and recommendations in a Final Report.

4.3.1.2 EVALUATION FRAMEWORK FOR ITS PROJECTS IN FINLAND

The Ministry of Transport and Communications of Finland has issued, in 2002, guidelines for the impact assessments of ITS projects, enabling the comparison of ITS projects to one another and other investment projects from the point of view of impacts and economic feasibility. To ensure that all projects cover the essential points for decision-making, the guidelines present a systematic method for dealing with impacts (MOTC, 2002).

These guidelines applied to ITS project evaluation derive from a general project evaluation framework created also by the Ministry of Transport and Communications that *"is designed for use in evaluating extensive, government-funded development project, but its principles can also be applied to the evaluation of smaller projects and actions"* (MOTC, 2002, p. 12). This general framework is presented below, and according to the guidelines of the finish Ministry of Transport and Communications it *"can also be used in ITS project evaluations"* (MOTC, 2002).

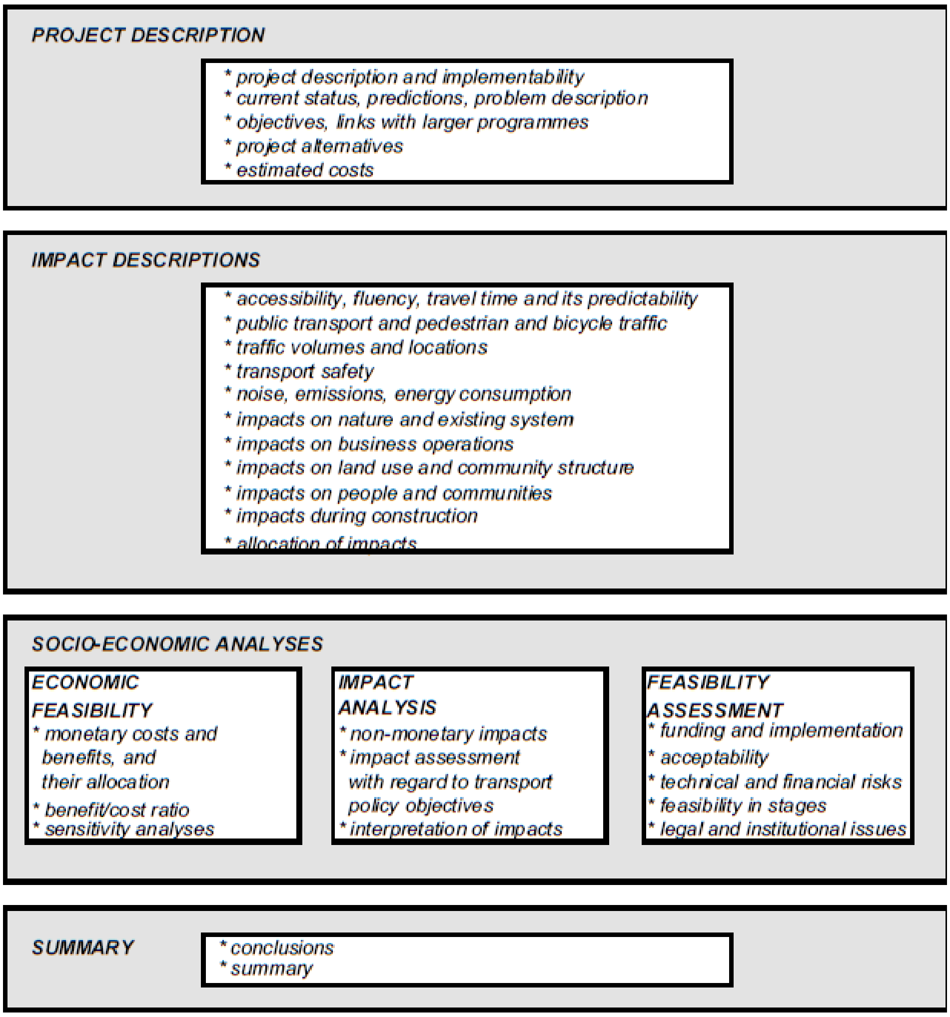


Figure 4.2 - Finish evaluation methodology. Source: (MOTC 2002, p. 13)

4.4 COST-BENEFIT ANALYSIS (CBA)

This is the most popular method used to evaluate transport projects (Salling & Leleur, 2011; van Wee, Bohte, Molin, Arentze, & Liao, 2014; van Wee, 2012) both in Europe (Barfod, Salling, & Leleur, 2011; Bristow & Nellthorp, 2000; Riedel & Dziekan, 2006) and in the United States of America (Lee Jr., 2000), and is also the dominant assessment tool used to evaluate ITS projects (Lee Jr., 2004; Zhicai, Jianping, & McDonald, 2006).

According to Stevens (Stevens, 2004), CBA is used in the context of ITS assessment and decision making in three different ways: CBA as a stand-alone quantitative method, CBA within quantitative and qualitative framework, or using CBA and MCA in the same evaluation methodology.

4.4.1 CBA AS A STAND-ALONE QUANTITATIVE METHOD

Both the public and the private sector use CBA as a stand-alone quantitative method to guide ITS implementation. The European Commission's "Guide to cost-benefit analysis of investment projects" is seen as the main reference in Europe on the application of CBA to assess ITS investment, and this guide suggests the following methodology (European Commission 2008):

Step 1 - Definition of objectives, project identification and results of feasibility studies

After a need has been identified it is essential to define clearly the objectives to be accomplished. The available alternatives of a project should be presented, describing how they would meet the objectives. According to this guide "a project can be defined as an operation comprising a series of works, activities or services intended to accomplish an indivisible task of a precise economic or technical nature; one which has well defined goals" (European Commission, 2008, p. 32). It is also important to prove, through a feasibility study, that the selected project is the most suitable alternative between the options considered.

Step 2 - Financial analysis

This step aims at computing the project's financial performance indicators. This analysis is normally done from the perspective of the owner of the infrastructure, and should use the methodology of the discounted cash flow (DCF) analysis, which comprises two main aspects:

1. Only cash flows are considered, and non-accounting items like depreciation and contingency reserves must not be included in the DCF. Every cash flow has to be considered in the year which they occur and over a reference period (time horizon). According to the European Commission (European Commission 2008), the reference period for Telecommunications projects should be of 15 years. If the project has any component that is still economically useful after the end of the reference period, it should be considered a residual value. Preferably, this should be estimated as the present value of expected net cash-flows during the years of economic life after the end of the project.
2. The time value of money has to be considered, i.e., all future cash flows have to be discounted to the present with the use of a discount rate, which the European Commission recommends to be 5%.

The project's evaluation is based on the differences in the costs and benefits between the scenario with the project and an alternative scenario without the project.

The financial analysis of a major project's CBA has the following objectives:

- Evaluate the financial profitability of the investment: estimate the financial net present value and the financial rate of return of the investment.
- Analyze the financial sustainability of the project: the undiscounted net cash flows need to be positive through the entire time horizon of the project.

Step 3 - Economic analysis

It is necessary that project inputs are valued at their opportunity cost and outputs at consumers' willingness to pay. This economic analysis is undertaken from the perspective of the society. The starting point is the cash flows of the financial analysis. Some adjustments have to be made to determine the economic performance indicators:

- **Fiscal corrections**: deduction of taxes, subsidies and transfer payments.
- **Corrections for externalities:** externalities are positive or negative impacts that the project generates but they go beyond the project's scope, and these have to be estimated and valued.
- **From market prices to shadow prices:** Shadow prices reflect inputs' opportunity costs and consumers' willingness to pay for outputs, and these are computed by applying conversion factors to the financial prices.

After the estimation of economic costs and benefits, the methodology of DCF is applied, but a social discount rate should be used (usually 5,5%).

The suggested economic performance indicators that can be calculated for a project are: economic net present value, which should be positive; economic rate of return, which should be greater than the social discount rate; and benefit/cost ratio, which should be greater than one. Although, the European Commission refers that the more reliable of these indicators is the economic net present value.

Step 4 - Sensitivity and risk analysis

The sensitivity analysis aims to identify the critical variables, which is accomplished by varying the project's variables a given percentage and observing the variations of the indicators. Variables should be varied one at a time, and the others should be kept constant. The Guide suggests that critical variables are those that with a 1% variation give rise to corresponding variation of 5% in the Net Present Value's base value (but different criteria may be adopted).

The risk analysis addresses the probability with which a change in a variable may occur. Probability distributions are assigned to the critical variables, with which the probability distributions of the financial and economic performance indicators are estimated. This analysis provides interesting statistics like: expected values, standard deviation, coefficient of variation, etc.

It is important to note that a sensitivity analysis is always possible to do, but a risk analysis may not (e.g. lack of historical data on similar projects).

4.4.2 CBA WITHIN A QUANTITATIVE AND QUALITATIVE FRAMEWORK

Another example is the use of CBA within a quantitative and qualitative framework, where the strengths and contributions of both CBA and qualitative evaluations are recognized, placing both within a general evaluation framework. One example is the evaluation framework of the European project STRAIGHTSOL.

STRAIGHTSOL stands for "STRAtegies and measures for smarter urban freIGHT SOLutions" and is a recent European project (started in 2011) that has in its consortium entities from the countries: Belgium, Greece, Netherlands, Norway, Portugal, Slovenia, Spain, and United Kingdom.

The STRAIGHTSOL consortium developed a new assessment framework for the evaluation of measures applied to urban-interurban transport interfaces. According to Macharis *et al*. *"The STRAIGHTSOL framework can be used by a private company who thinks of several possibilities to* *change its delivery operations and needs an objective and comprehensive basis to make a choice. The framework can also help local governments to design and/or fine tune their urban freight policy and to make sure that the policy is in line with the goals they want to reach. Every actor who is confronted with a problematic urban delivery situation and thinks of several solutions to deal with it can turn to the STRAIGHTSOL framework for structural and comprehensive support in the decision on which solution to choose. The framework can be applied in different stages of this decision making process, before or after measures are tested or implemented"* (Macharis et al., 2011, p. 5). Therefore, this evaluation framework can be used by the decision-makers of the public and private sector.

This evaluation framework consists of three stages, each one with several steps, as we can see in the figure below:

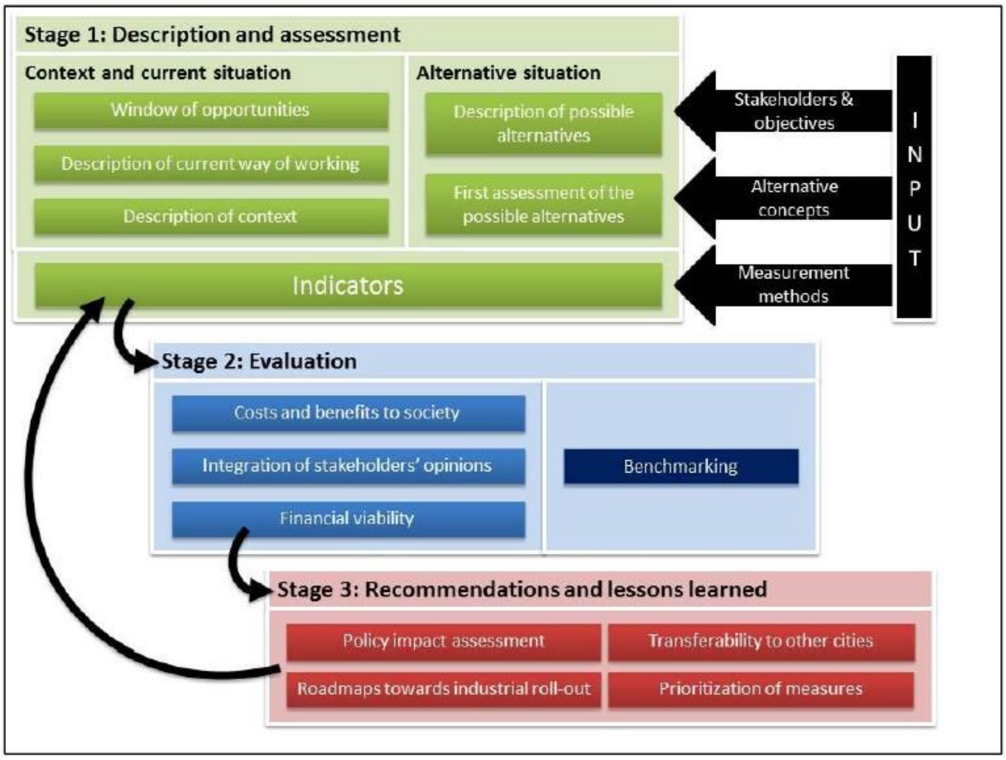


Figure 4.3 - STRAIGHTSOL evaluation framework. Source: (Macharis et al. 2011)

The stage 2 of this evaluation framework has the objective of providing a global analysis of different urban freight initiatives or measures, and aims at covering the most possible cases. Since a single methodology can't provide that type of global analysis, the project's evaluation framework uses three evaluation tools: Social Cost-Benefit Analysis (Social CBA), a Business Model Concept and a Multi Actor Multi-Criteria Analysis.

4.4.3 USING CBA AND MCA IN THE SAME EVALUATION METHODOLOGY

This method of using CBA in the assessment of ITS implementation attempts to take the multiple impacts of a project into consideration in a balanced manner. The combination of CBA and MCA pretends to take advantage of the strengths of both evaluation tools.

The benefit/cost ratio or other CBA performance indicator may be used as a criterion of the MCA or the costs and benefits may separately contribute to a number of criteria (Stevens, 2004).

There are also examples of combining CBA with MCA to proceed with an evaluation of economic and strategic impacts within transport projects (Gühnemann, Laird, & Pearman, 2012; van Wee, 2012), and these include the case study of Barfod et al. (Barfod et al., 2011) where they create a composite model for assessment (COSIMA) as a decision support system:

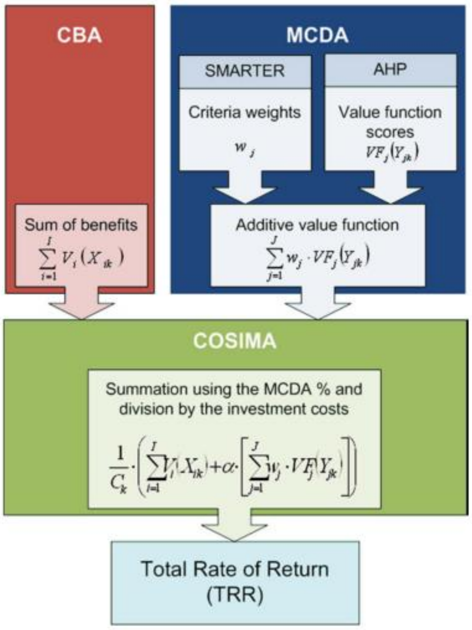


Figure 4.4 - Overview of the steps in the COSIMA. Source (Barfod et al. 2011).

4.4.4 LIMITATIONS OF CBA

Despite the popularity of CBA to evaluate transport projects, this method has limitations, some of which will be discussed in this section. These technical limitations have been pointed out in the work of several authors (Hyard, 2012; Riedel & Dziekan, 2006; Thomopoulos, Grant-Muller, & Tight, 2009; van Wee et al., 2014; van Wee, 2012), and they can be divided, in general, in two groups: those regarding data issues and evaluation, and those referring to CBA within the wider social context.

The limitations concerning data issues will be discussed below. According to Stevens (Stevens, 2004) there are issues concerning the availability of data when the ITS system that is going to be implemented is new. Without the prior experience there is the need to estimate the data needed to complete a CBA from available evidence using expert judgment.

Stevens also highlights that it is a common practice to perform assessments as ITS solutions move into implementation, however these usually lack in detail. These assessments during the implementation should be carried out not for the benefit of the projects that are underway, but to provide data for future projects.

Generally, the evaluations aim at assessing if the objectives of an ITS systems are being achieved. But there is a lack of assessments of the dis-benefits like increased congestion and subsequent pollution. Consequently, there is an issue concerning the scope of the measurements made and the consequent impact on overall CBA calculations. This usually results in well-publicized successful implementations that don’t have the dis-benefits well reported.

The monetization of impacts is dependent on economic and social factors such as, for example, income, and the methods used to proceed with those valuations of impacts are more focused on the short-term than on the long-term. The valuation of factors such as the value of time, value of accidents or even the selection of the discount rate involves policy judgments, which underlines the importance of sensitivity testing of all CBA results.

CBA is based on the possibility of expressing the most important effects in monetary terms, which is often no possible. CBA is a method used to measure efficiency, but the objectives of decision makers may include other objectives that have nothing to do with efficiency (i.e. attracting positive publicity or serving a particular community). This may lead the decision makers to choose qualitative methods of evaluation, rather than the quantitative method that is CBA, in order to be able to include the qualitative impacts that result from the implementation of ITS solutions.

Stevens refers that the socio-economic approach of this method of evaluation takes costs and benefits of all stakeholders in an economy into account. There can be positive effects for one stakeholder that are negative for another. So, seeing the society as a whole, the positive and negative effects are summed, but the method doesn't take into consideration the distribution of effects between all stakeholders, which may affect the way that an ITS project is perceived.

Studies typically focus on the performance of the whole transport systems rather than the ITS tool, making it difficult to isolate the impacts of any particular ITS solution. This holistic approach is necessary when, as frequently occurs, benefits in one ITS component may be offset by consequent dis-benefits elsewhere on the network. Benefits can be magnified by using complementary ITS applications (Stevens, 2004).

Sometimes there are context issues when a CBA evaluation is taken into consideration. This group of limitations concerns the case of a project that has a very high benefit/cost ratio, but the project has not been implemented. This is usually due to the fact that the costs may be greater than the available resources or a decision-maker's willingness to pay. However, there may be other reasons behind the decision to not undertake an implementation of ITS solutions, despite it being apparently beneficial.

Other examples comprise the addition of more stages of filtering after an economic evaluation, which were included in the guidelines for the evaluation of ITS projects in Finland (MOTC, 2002). The finish guidelines highlight the issues of compatibility with policy objectives, acceptability, technical and financial risk and legal and institutional issues.

In the City Pioneers project (Stevens, 2004, p. 104) it were highlighted the most important deployment issues that could result from the implementation of ITS applications. Assessment of costs, benefits and impacts is only one among the 10 major deployment issues underlined.

Another example is the consideration of both cost-benefit analysis and deployment issues in parallel within the risk management context within the European project ADVISORS (Stevens, 2004, p. 105).

Another group of problems was identified by the author Amartya Sen (Sen, 2000) in the paper called "The Discipline of Cost-Benefit Analysis". Sen highlights a third group of problems posed by CBA: issues related to a lack of concern about evaluation.

This group is where Sen places the problems regarding a lack of concern about the intrinsic value of freedom. Sen observes that “mainstream” CBA does not evaluate substantive that is real, individual freedoms. According to Sen, the CBA’s lack of evaluation of freedoms is a serious problem: ‘‘the neglect of the freedoms that people enjoy is no less serious a limitation than the neglect of rights’’ (Sen 2000, p.944). In his opinion, this problem is the result of the ‘‘narrow’’ nature of the consequentialism of the analysis. Sen criticizes the method of CBA because it is linked to the welfarist nature of the analysis.

However, Sen sees a solution to the problem posed by CBA: ‘‘It is possible for consequential cost-benefit analysis to takenote of the substantive freedoms that people have (formally this will require valuation of opportunity sets, and not merely ofthe chosen alternatives)’’ (Sen 2000, p.944).

4.5 OTHER COMMON EVALUATION METHODS

Despite the popularity of CBA, according to Zhicai *et al* (Zhicai et al., 2006) and Stevens (Stevens, 2004), there are other two assessment tools that are commonly used in the evaluation of ITS projects: cost-effectiveness analysis (CEA) and multi-criteria analysis (MCA).

The **cost-effectiveness analysis (CEA)** methodology compares several alternatives of a project that have a single common effect, but the effect of each alternative may differ in magnitude. The objective is to select the best project, i.e. the project that maximizes the desired output with the lowest possible net present value of costs. This type of method provides results that are useful to decide between those projects whose benefits are very difficult to measure but their costs can be easily predicted. According to the “Guide to Cost-Benefit Analysis of investment projects” of the European Commission (European Commission 2008), this methodology is commonly used to evaluate healthcare programmes, and also to assess scientific research, education and environmental projects.

In general, CEA aims at solving the problem of optimizing the allocation of resources that is normally presented in two forms (European Commission 2008):

- With a fixed budget and a varying scope of alternatives, the objective is to choose the one that maximizes the desired output, which is measured in terms of effectiveness (*E*);
- For a desired level of *E*, the alternative chosen has to be the one that minimized the cost (*C*).

The usual procedure to compare the alternatives of a project is to produce a cost-effectiveness ratio (CER) (Pearce, Atkinson, & Mourato, 2006):

$$CER = \frac{E}{C}$$

However, the European Commission (in the “Guide to Cost-Benefit Analysis of investment projects”) states that the correct comparison has to be based on ratios of incremental costs to incremental outputs, because this method informs us how much we have to pay by the extra effectiveness of the more beneficial alternative. So, the European Commission suggests that to compare project (a) with project (b) with a CEA, we must calculate the ratio:

$$R = \frac{C_a - C_b}{E_a - E_b} = \frac{\Delta C}{\Delta E}$$

And it is this ratio (*R*) that is used to compare the alternatives to a project, leading to the choice of the one that has the higher *R*.

In conclusion, CEA is more useful when used to compare alternatives to a project where only a single output is important. This fact limits the possibilities of application of CEA, because in most cases, projects have several impacts that do not fall only in a single effectiveness measure. Moreover, because CEA does not take into account the benefits, this methodology only evaluates technical efficiency, rather than allocative efficiency. CEA can only guide the decision-makers on which of several alternatives to select, because it ranks the list of possible alternatives.

The methodology of **Multi-Criteria Analysis (MCA)** is similar to CEA but instead of a single measure of effectiveness, this method of evaluation uses multiple criteria, each with a different 'weight', to select one alternative among all the possibilities. MCA is designed to deal with a varying scope of objectives that that can't be aggregated through shadows prices and welfare weights, as in CBA.

There are several approaches to proceed with a MCA. The European Commission suggests the following steps (European Commission 2008):

1. Specify the objectives and the variables in which they will be measured. Two objectives should not express the same idea, but the gain in one could partly preclude the achievement of the other;
2. Assign weights to each objective to reflect the importance of each of them given by the decision-maker;
3. Define the appraisal criteria that translate the priorities of each stakeholder involved, or specific evaluation features;
4. Perform an impact analysis: describe the effects that every criterion produces. The description can be qualitative or quantitative.
5. Predict the outcome of the project in terms of the selected criteria. Each alternative is given a different score, or a normalized value, that is calculated based on the results of the previous step;
6. Calculate the final outcome of every alternative of the project, which is a weighted average of scores. The results can be compared to select the best alternative of a project (according to the criteria and weights that were selected).

The formula for the final score of each alternative using the simplest MCA is:

$$S_i = \sum_j m_j S_j$$

where *i* is the ith option, *j* is the jth criterion, *m* is the weight, and *S* is the score (Pearce et al., 2006).

As in CEA, where effectiveness is compared to cost in the ratio CER (or R) with a MCA we can't conclude whether or not it is worth adopting any alternative at all. We can only decide which alternative to choose from a list of possible alternatives. Therefore, these two methods of evaluation are “efficient” to secure maximum effectiveness for a given unit of cost, but may be “inefficient” in terms of economic efficiency.

It is important to refer that MCA is often criticized has being subjective in the determination of weights that are used, because they can be easily manipulated (van Wee, 2012).

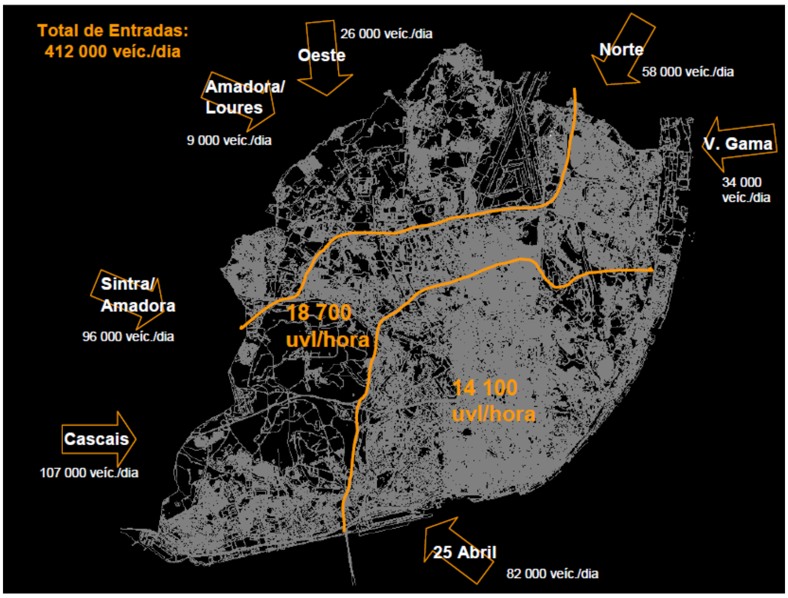
In conclusion, “these approaches [CEA and MCA] cannot be seen as substitutes for CBA but rather as complements for special reasons, or as a rough approximation when actual CBA is impossible.” (European Commission, 2008, p. 68)

5 CASE STUDY: TWO DIFFERENT TECHNOLOGIES

5.1 CONTEXT AND CURRENT SITUATION

5.1.1 LISBON

Lisbon is the capital city of Portugal and according to the 2011 Census made by the *Instituto Nacional de Estatística* (INE) it has a population of 547.733 inhabitants, but the population of the metropolitan area of Lisbon is around 2 million inhabitants (2.042.477 to be precise, according to the same 2011 Census made by INE). According to the Monitoring Indicators of the Municipal Plan elaborated in 2012 by the Municipality: the urban area is around 84,6 km^2, the population density is 6.674 inhabitants per km^2 and the rate of the number of vehicles is 281 vehicles per 1.000 inhabitants (Câmara Municipal de Lisboa, 2012); and the relevant numbers about parking and traffic are: 152.400 on-street parking places from which 40.150 are paid (Câmara Municipal de Lisboa, 2011), and 412.000 vehicles entering Lisbon daily (Câmara Municipal de Lisboa, 2010).



Source: (Câmara Municipal de Lisboa, 2010)

Figure 5.1 - Vehicles entering Lisbon daily

5.1.2 EMEL

EMEL stands for *Empresa Municipal de Estacionamento de* Lisboa (Municipal Parking Company of Lisbon) and was created in 1994 on a resolution of the municipal council of Lisbon. The main objective is to regulate and discipline the on-street parking, charging it with the aim of encouraging its short duration, thus fostering turnover. EMEL is 100% owned by the City with independent management, has its activity regulated by the municipality, the tariffs and prices are established by the municipality and operates under the national legislation on parking and traffic management. The staff members are recognized as enforcement agents of authority that can: issue tickets, warnings; and tow or “boot/clamp” (Farias, 2012).

Figure 5.2 - EMEL's logo. Source: (Rodrigues et al., 2012)

Currently the company has 385 employees, 25 “booting” teams, 60 vehicles (vans and scooters), 1.500 pay & display machines across the city and is responsible for the following:

- On-street parking management and enforcement (ca. 40.000 parking spaces);
- 5 Parking Garages and 17 Parking Lots (ca. 3.600 parking spaces);
- Managing of 4 historical neighbourhoods with controlled access;
- Manage the public charging points for electric vehicles;
- Park & Ride solutions;
- Mobility solutions; and
- Mobility and Parking Consultancy.

In the headquarters is the Operations Control Centre (OCC) that works 24 hours a day and 365 days a year, monitoring and analysing data in real time and is where the operational decisions are made. The OCC monitors the on-street enforcement operations, the controlled access to old neighbourhoods, off-street parking lots and maintenance activities (Farias, 2012).

5.1.3 CURRENT WAY OF WORKING (AS-IS SITUATION)

The municipal regulation of loading/unloading activities in the City of Lisbon was approved by resolution in July of 2004, but it was then suspended in 2007 “until the technologic solutions that are behind it show a degree of suitability and effectiveness compatible with the goals that are pursued by the concerned regulatory” (Rodrigues et al., 2012). Therefore, there is no legislation to regulate loading/unloading activities, only the legislation on road traffic and the municipal legislation. And there are three entities that monitor these activities: the Municipal Police, the Public Safety Police and also EMEL, this last one being only authorized to fine private vehicles parked on LUPBs without the presence of the driver, on the respective concession area. This situation means that there is no uniform criterion of activity in the City.

Additionally it is clear that there is a lack of spaces for freight deliveries in Lisbon and also that there is an abusive occupancy of the available spaces by private vehicles. These lead to road congestion problems and often blockage of roads (when trucks often stop at narrow streets for quick deliveries) and generalisation of illegal parking – such as: freight vehicles parked on sidewalks, double-parked or parked on regular parking spaces, and private cars parked on LUPBs (Andersen, Eidhammer, & Østli, 2012).

Nevertheless, EMEL’s Parking Officers monitor both types of on-street parking in the city of Lisbon simultaneously, whether it is the regular parking of private cars or LUPBs. The current process of enforcement (or As-is situation) has three independent participants:

- **Parking Officer;**
- **OCC;**
- **Towing Vehicle.**

This is better explained on figures Figure 5.3 and 6.4.

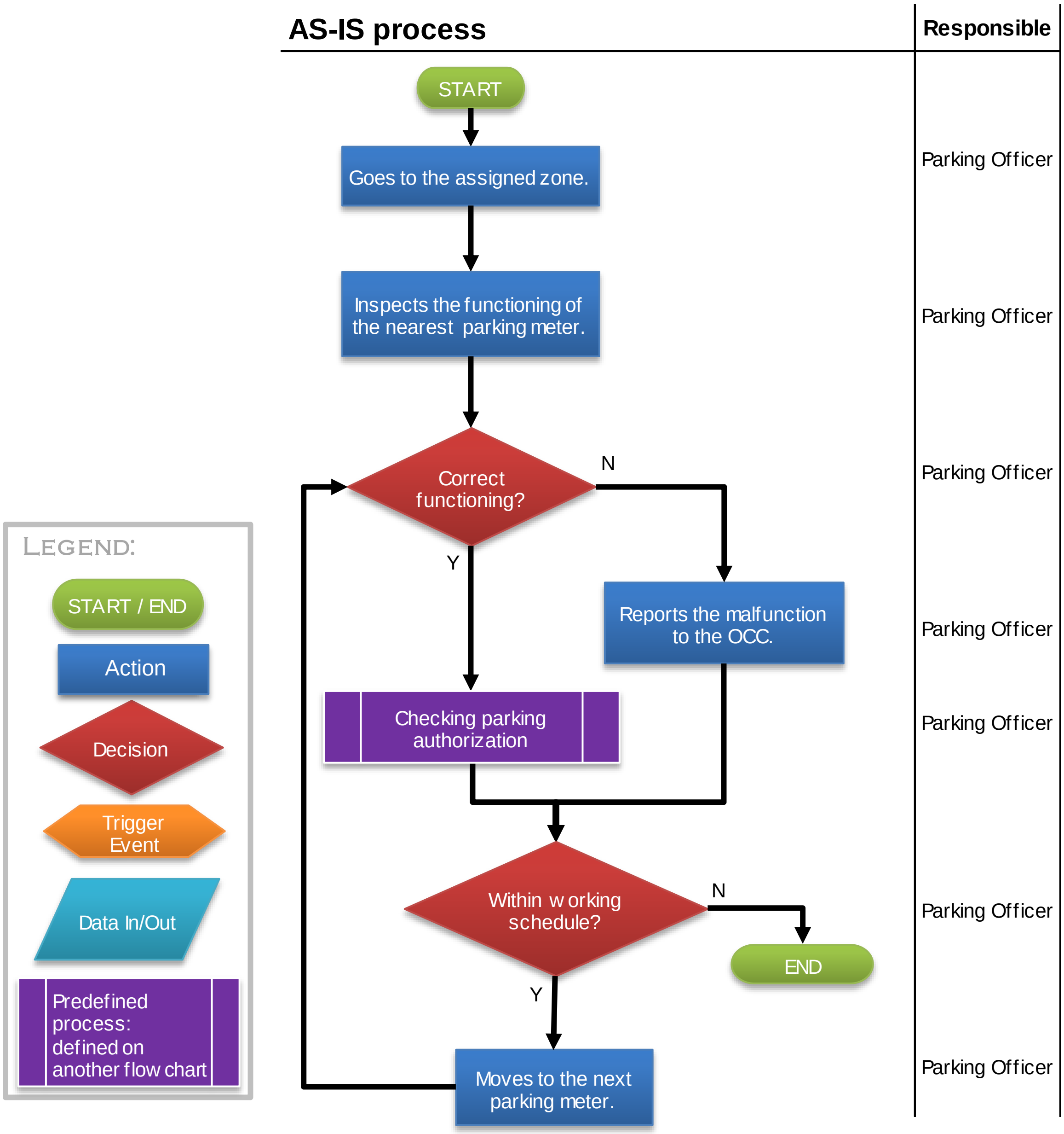


Figure 5.3 - Flowchart of Parking Officers' current monitoring/enforcement

Each week is assigned a parking zone for each Parking Officer, and he/she goes to the assigned zone by foot, by public transport or on an EMEL's scooter. When he/she arrives, first, he/she inspects the parking meter, to ensure its correct functioning, and then he/she proceeds to checking the parking authorization of every vehicle parked within the area allocated to that parking meter (better explained on the next flowchart). When he/she has checked all the vehicles, he/she moves to the next parking meter. This process is repeated until the end of the working schedule.

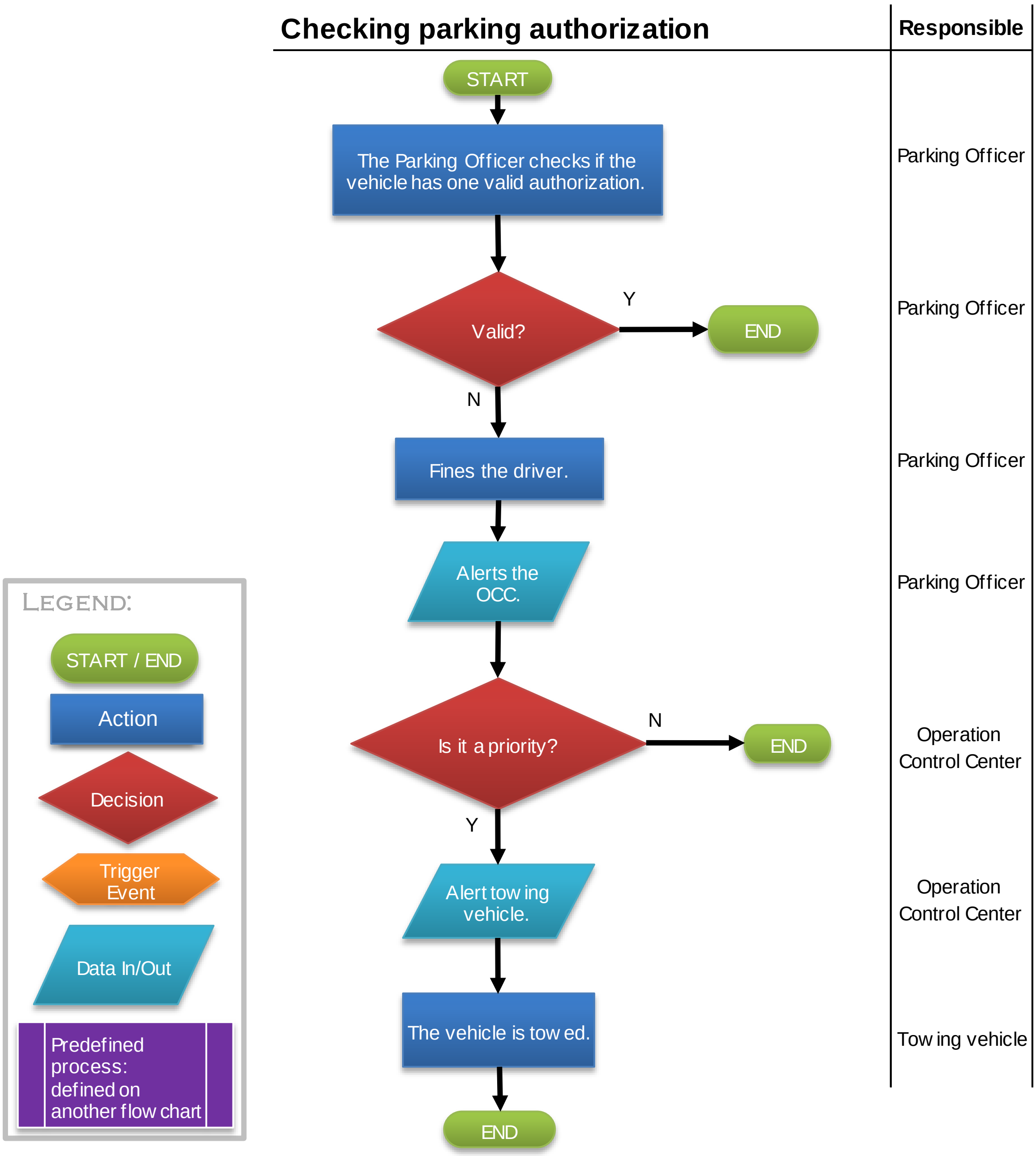


Figure 5.4 - Flowchart of the predefined process "Checking parking authorization"

When checking the parking authorization of any vehicle, the Parking Officer has to check all situations of the non-tariff system and the tariff system.

The non-tariff system encloses the following invalid situations: parked in front of a garage; blocking another vehicle; parked on crossroads or sidewalks; double parking; and the exceptions (e.g., handicaps, load/unload, construction sites, etc.) that are valid with the correspondent permit. While the tariff system refers to valid paid situations, such as: permits (resident and shopkeepers); ticket from parking meters; scratchers; and smart park device.

If the vehicle doesn't have a valid authorization, the Parking Officer fines the vehicle and then notifies the OCC describing the situation and the vehicle in question. The OCC then decides if this is a priority situation, and if it is, alerts the towing vehicle that a vehicle needs to be towed. This process ends when the vehicle is towed.

5.2 EMEL PILOT IN LISBON

Since the obstacle of the pursuit of the regulation of loading/unloading activities of the City of Lisbon was due to technological questions, it was needed to ensure, in order to start revising the regulation, that there was an efficient monitoring, in real-time, that didn't encumber the City of Lisbon. Therefore, the Municipality of Lisbon ordered that EMEL would be responsible for the implementation of a pilot project that ensured the appropriateness and feasibility of the technological solutions (Rodrigues et al., 2012). Additionally, this pilot project would help to mitigate (or solve) the significant conflicts between urban freight operations, pedestrians, private car users and public transport.

Therefore, the purpose of EMEL's pilot project was to help finding the adequate solution by (Andersen, Eidhammer, & Østli, 2012):

1. Testing and identifying technologies for controlling and monitoring cargo activities (loading/unloading) in the urban context.
2. Providing evidence and the grounds for developing the Municipal Regulation on loading and unloading operations
3. Applying the chosen technology to the rest of the city.

5.2.1 STAKEHOLDERS

The stakeholders affected by the implementation of this pilot project were:

- Authorities (EMEL / Municipality), who would be implementing the demonstration;
- Logistic Service Providers/Transport operators, who expectedly would increase the efficiency in their loading/unloading operations;
- Freight receivers (shopkeepers), who would benefit from more reliable deliveries;
- Citizens and other road users, who at one hand would be less affected by freight deliveries, but on the other hand could face more restricted parking regimes.

5.2.2 LOCATION

The chosen place was the Guerra Junqueiro Avenue, because it has a great diversity of shops (that range from small shops to large ones) and also a variety of loading and unloading practices.

This avenue is 320 meters long and is a one-way street with regular parking and has LUPB on both sides: 8 on the West side, and 9 on the East side. The parking timetable is from 9:00 to 19:00 on weekdays, and from 9:00 to 13:00 on Saturdays.

Source: (Rodrigues et al., 2012)

Figure 5.5 - Guerra Junqueiro Avenue in Lisbon

The pilot started on December 5th 2011 and ran until March 17th 2012 (15 weeks); these dates were chosen to cover the Christmas period because it is usually one of the busiest of the year.

5.2.3 OBJECTIVES

With the implementation of this pilot project, EMEL expected to reach the following immediate results (Andersen, Eidhammer, & Østli, 2012):

- **Benefits for the city:**
  - Reduction of road traffic offences;
  - Reduction of freight activities duration;
  - Reduction of conflicts with other public space users.
- **Benefits for Transport Operators:**
  - Improve general satisfaction level of Transport Operators;
  - Increase vehicle rotation (i.e. increase parking place availability).
- **Benefits for Shopkeepers:**
  - Improve general satisfaction level of shopkeepers.
- **Benefits for EMEL (choice of best technology):**
  - Improve parking surveillance efficiency;
  - Dimming of peak period.

It was also expected that the use of ITS solutions would help to mitigate (or even solve) the problems detected on this avenue (listed above).

On the long term, it was expected that the results of this pilot project would help choosing the right technology for controlling and monitoring loading and unloading activities on the whole city, and to provide evidence and the grounds for developing the Municipal Regulation on loading and unloading operations.

5.2.4 **DESCRIPTION OF ITS ALTERNATIVES**

The pilot project tested two ITS solutions simultaneously that are explained below.

5.2.4.1 To-Be Vehicle Detection Sensor (VDS)

The vehicle detection sensor is installed on the ground and detects the magnetic field above, which can be influenced by the proximity of vehicles, but also (although with lower impact) by other smaller magnetic objects (e.g. cans), and even by temperature or humidity. When the magnetic field changes more than a certain value (previously defined), the system interprets that as an entrance or exit of a vehicle in the LUPB.

Source: author
Figure 5.6 - One of the VDS

The "To-Be VDS" alternative is the enforcement process based on the vehicle detection sensors, and it is divided in two processes that occur simultaneously: usage and enforcement. There are four actors involved in this enforcement process: **VDS**; **Server**; **OCC**; and the **Parking Officer**.

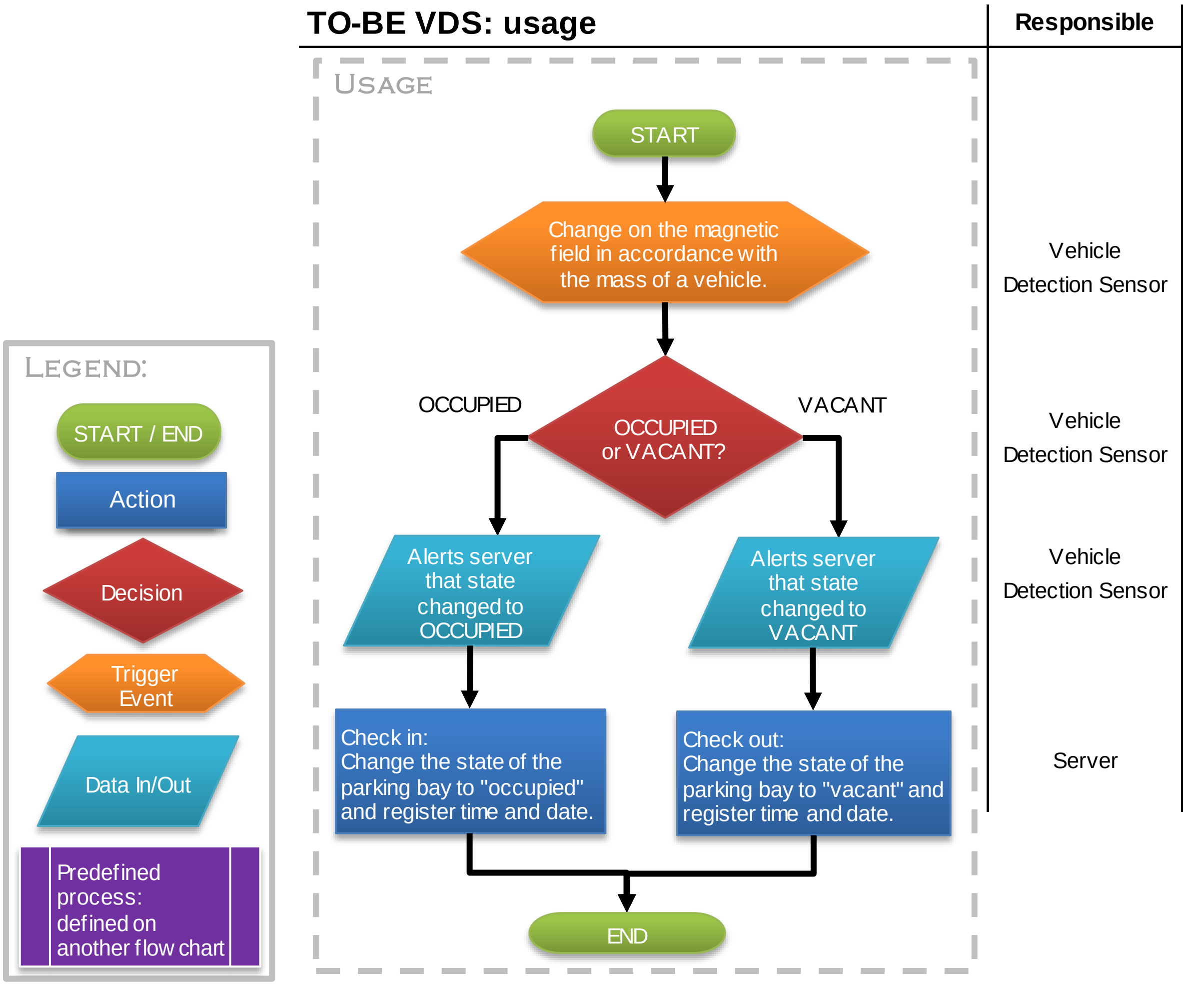


Figure 5.7 – Flowchart of the usage process TO-BE VDS alternative

The **usage process** starts when the VDS detect the entrance or exit of a vehicle in the parking place and, if the magnetic field increased, it means that a vehicle entered the LUPB (OCCUPIED situation); but if the magnetic field decreased, it means that a vehicle has left the LUPB (VACANT situation). The VDS sends the new information to the Server, which then proceeds with the check-in, in the case of an OCCUPIED situation; or with the check-out, in the case of a VACANT situation.

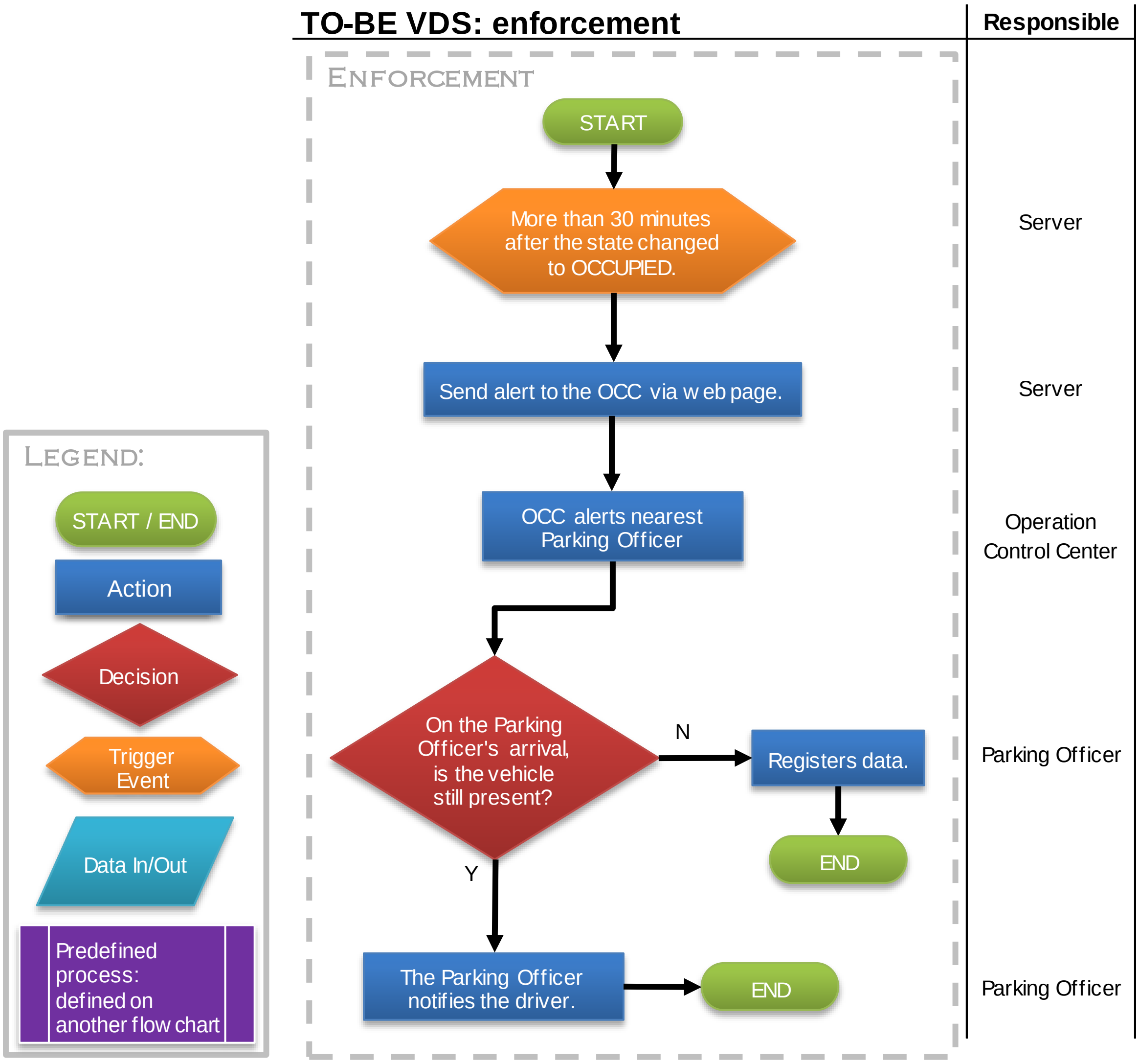


Figure 5.8 - Flowchart of the enforcement process of the TO-BE VDS alternative

As to the **enforcement process**, this one starts when the Server detects that a vehicle has been parked more than 30 minutes, i.e., the state of a sensor hasn't changed from OCCUPIED to VACANT for the last 30 minutes. When that happens, the Server sends an alert to the OCC, which then informs the nearest Parking Officer that he needs to go to the LUPB where there is a road traffic offence. When the Parking Officer arrives he/she inspects the LUPB and if there is a vehicle parked he communicates with the OCC to confirm if it still on infringement. In the case of infringement the Parking Officer notifies the driver (as explained above the driver cannot be fined as there's no regulation for freight operations), but if the infringing vehicle is no longer present, the Parking Officer only registers that information.

5.2.4.2 *To-Be Adapted Parking Meters (APM)*

These parking meters issue special tickets for 30 minutes of free parking for unloading/loading operations (like those on the Figure 5.10). These APM are activated when a person exposes a contactless card that was previously given to shopkeepers and transport operators (see below). The ticket must be put under the windshield to be verified by the parking officers. If the 30 minutes period expires, the parking officer may only notify the driver (as there's currently no regulation for freight operations the driver cannot be fined) (Andersen, Eidhammer, Milan, et al., 2012).

The whole enforcement process is better explained below. This process is also divided in two processes that occur simultaneously: usage and enforcement. But in this case the actors involved in the process are: **Driver**; **Shopkeeper**; **APM**; and the **Parking Officer**.

Source: author

Figure 5.9 – The Adapted Parking Meter.

EMEL - Emp. Pública Mun. de Mob. e Estacionamento de Lisboa, E.E.M.
Cont. 503311332 Rec : 6656 Parquímetro n. 022/101

CARGAS e DESCARGAS

ESTADIA ATÉ: 28-12-2011 16H53 ZONA: 22-03

ENTRADA: 28-12-2011 16H23

Colocar no interior do veículo de forma a ser legível a data/hora de estacionamento.

Colocar no interior do veículo de forma a ser legível a data/hora de estacionamento.

Source: author

Figure 5.10 – The special parking ticket

Table 5.1 - List of shopkeepers or transport operators to which it was given one or more contactless cards

8&80	Farmácia Imperial	Mundo do Café Delta
Astro	Foreva	Néctar
Astro 2	Geovanni Galli	Oriversaria Santo António
Atlantis	Hisa	Pé de Meia
Benneton	Intimo Tuyo	Perfumaria Casquilho
C&A	Jarda	Perfumes & Companhia
Calzedonia	Le tailleur	Petit Patapon
Carol	Mango	Pull&Bear
Celta	Marionaud	Quer que Embrulhe
Chicco	Massimo Dutti	Ricardo e Ricardo Joalheiros
ChronoPost	Mercearia Creativa	SpringField
Cortefiel	Mexicana	Stefanel
DHL	Mini Surf II	Stoc Casa
Elady	Minicopa	Sweets for my Sweets
Esquina	Multi Ópticas	T Shirt's and all
		Zara

The **usage process** begins when a contactless card is exposed on the APM by the Driver of the freight vehicle or the Shopkeeper that is going to receive the delivery. Then, the APM checks if the card is within expiry date and hasn't been used on the last two hours, i.e., if the card is valid.

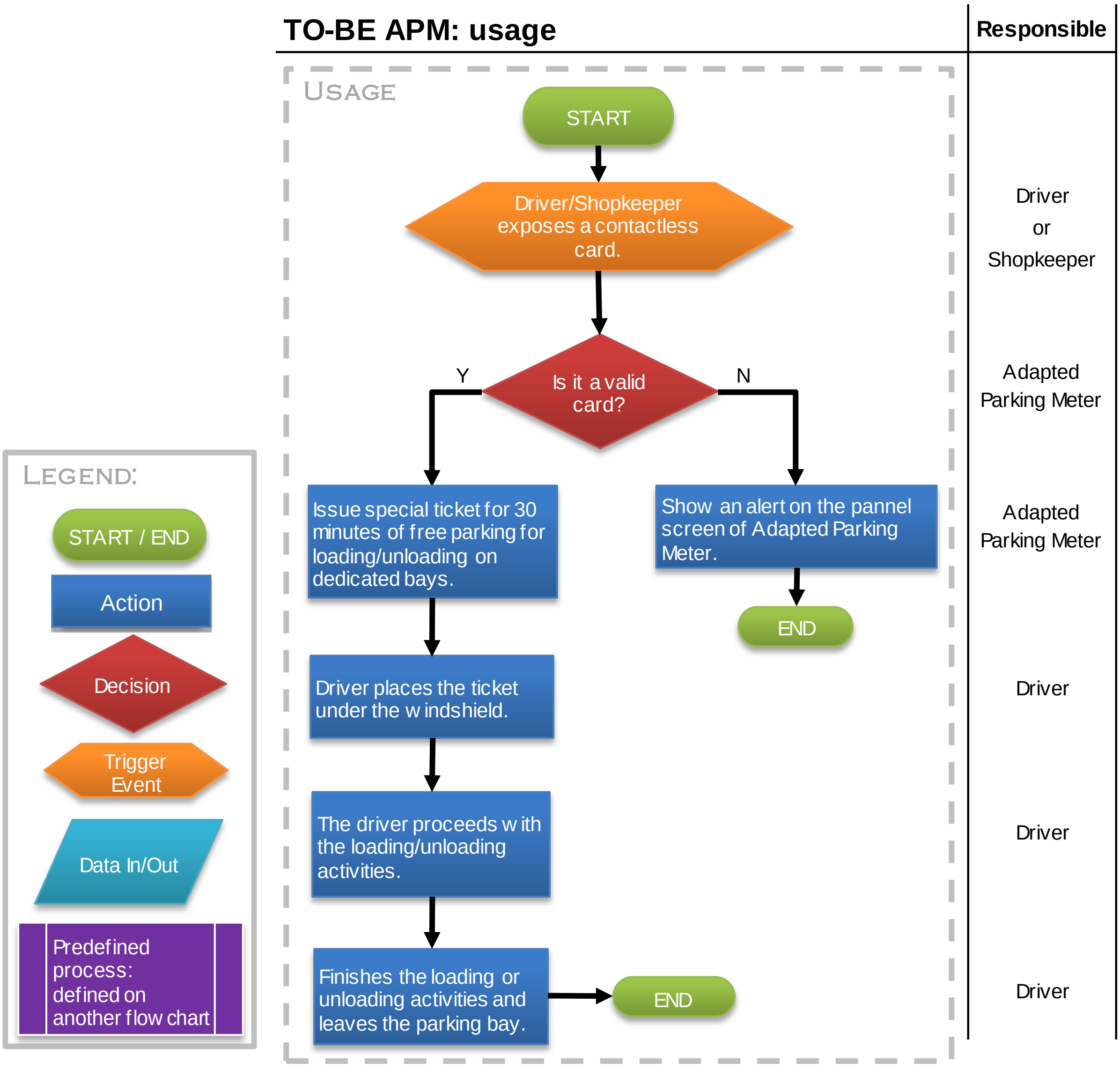


Figure 5.11 - Flowchart of the usage process of the TO-BE APM alternative

If the card is not valid, it is shown an alert on the panel screen of the APM. But if it is a valid card, the APM issues a special ticket for 30 minutes of free parking for loading/unloading on dedicated bays. After that, the driver/shopkeeper has to place the ticket under the windshield, and the loading or unloading activities take place until they finish and the vehicle leaves the LUPB.

The other process is about the enforcement, and this one is carried out only by the Parking Officer. This process starts when the Parking Officer arrives at the area allocated to the APM, where he/she inspects the vehicles on the LUPBs.

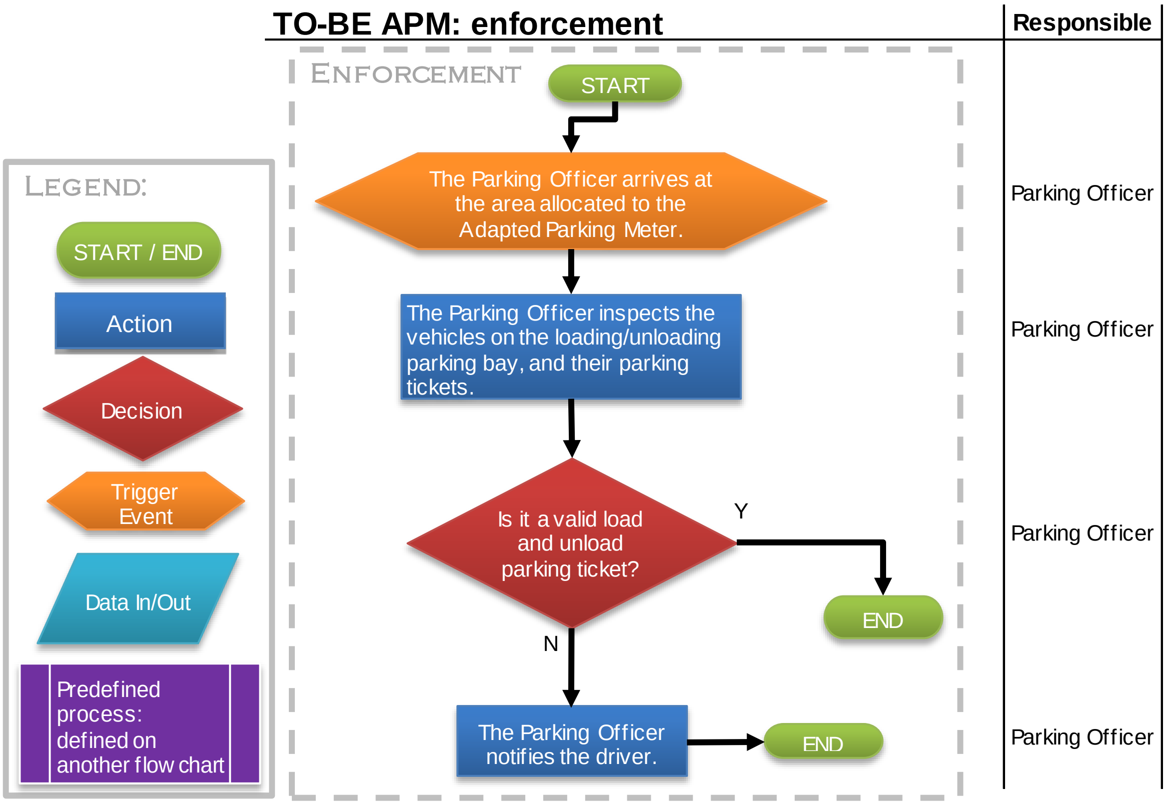


Figure 5.12 - Flowchart of the enforcement process of the TO-BE APM alternative

The Parking Officer notifies the driver of a vehicle that don't have a parking ticket or have a parking ticket invalid (expired the 30 minutes of free parking or with a wrong date), and fines the private cars that are illegally parked on the LUPBs.

5.2.4.3 STRENGTHS AND WEAKNESSES OF THE TECHNOLOGIES USED

Following the explanation of the enforcement process of both technologies, the author concluded that each alternative has several strengths and weaknesses, which are presented below.

- **Strengths**
  - **To-be VDS:**
    - Can monitor the parking spaces on a 24/7 basis;
    - It is not 100% dependable on Parking Officers;
    - Does not require interaction between the Transport Operators and the technology.
  - **To-be APM:**
    - The vehicles are clearly identified with the parking tickets;
    - The technology is more resistant.

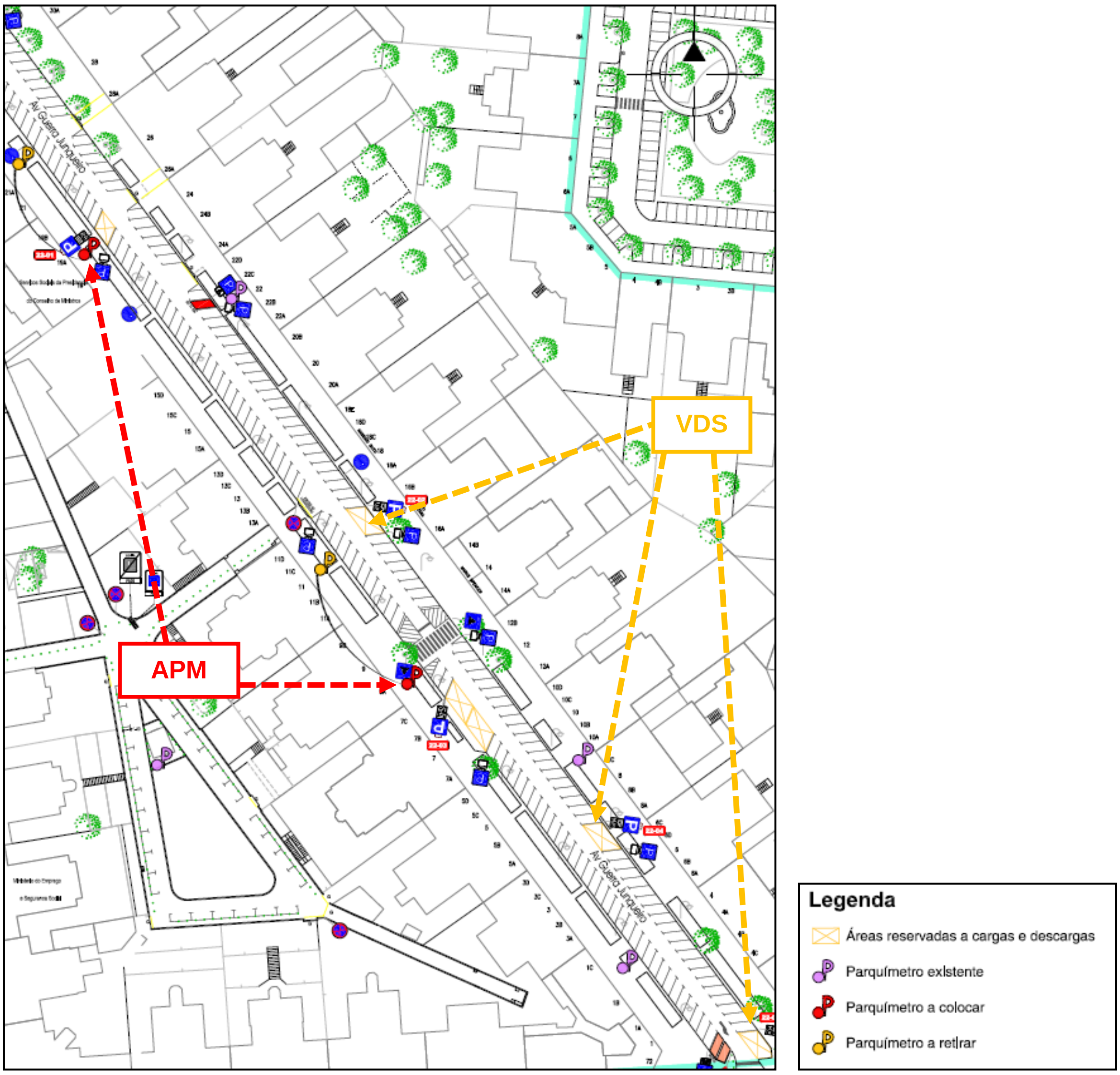
- **Weaknesses:**
  - **To-be VDS:**
    - May have some errors on detecting the presence of metallic masses;
    - The sensors can be damaged not only by vandalism acts, but also by other situations (if a heavy vehicle has a little rock on the tire this can cause a lot of damage or even the falling of a branch of a tree);
    - Does not differentiate between private vehicles and freight vehicles doing loading/unloading activities;
    - May present some errors because the temperature and humidity have some influence on the readings of the magnetic field.
  - **To-be APM:**
    - Highly dependable on the Parking Officers detecting the vehicles that need to be issued a parking ticket;
    - Requires interaction between the Transport Operators and the technology, which may be a difficulty when foreign Transport Operators have to use this technology.

To conclude, both alternatives can do the monitoring and enforcement of the use of the LUPBs, one being more automatic and the other being more precise on the identification of the vehicles.

The author is aware that these are only theoretical strengths and weaknesses, since he only uses the enforcement process as the basis to build this list. He is also aware that this list of strengths and weaknesses could be different if it was based on real-life data, i.e. on satisfaction surveys to the customers, shopkeepers, transport operators and EMEL officers, but these were not available at the time that this work was written.

5.2.5 IMPLEMENTATION

The implementation tasks occurred on the week before December 5th 2011, the starting day of the pilot project.



Source: (Rodrigues et al., 2012)

Figure 5.13 - Schematic of the pilot project on Avenue Guerra Junqueiro

On the West side of the avenue were installed three new parking meters that replaced the older ones. Two of which were APM, with the technology to read the contactless parking cards to be used on the pilot. The location of the APMs can be seen on the Figure 5.13. This system started to operate on the 5th December of 2011 and would monitor 8 parking places on two LUPB.

On the East side of the avenue were placed the VDSs on the ground of the LUPBs, one on each parking place (9 in total). These could only be operational on the 8th of December, due to difficulties with the glue since it was raining on the first day of the pilot. To complement this technology it was also needed to install 3 Gateway, on public lighting poles, to ensure the communication between the VDSs and the server. The VDS system started on full operation on the 8th December of 2011. The location of the VDSs is also visible on the Figure 5.13.

It was needed to paint the LUPBs on the avenue as well as to reinforce the vertical signs (see Figure 5.14) to allow the pilot project to run on real conditions.

Figure 5.14 - The vertical signs used on the pilot project. On the right is also visible the LUPB recently painted. Source: author

The implementation of the VDS and the Gateways can be seen on the following figures.

Figure 5.15 - On top: The two pictures show the glue where de sensor will be installed. On the bottom left we can see the sensor after being glued on the ground, and on the right it is the Gateway being installed, which is powered by a solar panel. Source: author

It was also needed to disseminate the project amoung the other stakeholders, i.e., the Transport Operators, Shopkeepers and Citizens. This dissemination was based on three type of informative flyers targeted to each different stakeholder, where it is a map explaining the location of: the LUPBs, the regular parking places, the VDS (green areas) and the APM (red areas). An example can be seen on the figure below (this one is targeted to the Transport Operators), where we can see on the left the starting date of the pilot project, then a brief explanation about the technology that is going to be used on each side of the street, and also the daily schedule on which the LUPBs will be monitorized by EMEL's pilot.

Source: EMEL

Figure 5.16 - Flyer delivered to the Transport Operators

6 CASE STUDY EVALUATION

This chapter starts with an explanation of the data limitations that occurred during the implementation of the pilot. These data issues led to the need to adapt the CBA's methodology proposed by the European Commission in the "Guide to cost-benefit analysis of investment projects" to the reality of the pilot implemented by EMEL.

The author then gives an overview of the situation before the pilot (called the "As-is situation"), followed by the presentation of the data that resulted from the implementation of both ITS alternatives. Using that data, the implementation of both ITS solutions is evaluated using a simplified version of the CBA (which is addressed in this work as the "Simplified CBA"), with a time-horizon of 15 years. Finally it is given a rough estimate of what to expect if the technologies would be implemented on all LUPBs in the city of Lisbon.

6.1 DATA LIMITATIONS AND METHOD ASSUMPTIONS

This dissertation faced some problems in obtaining data regarding the impacts that could result from EMEL's implementation of technology to ease the monitoring and enforcement of parking. In order to perform a CBA to the case study it was needed, at least, the following data: parking spaces rotation rates, numbers of the abusive occupancy, operating costs of EMEL, polluting emissions, safety of pedestrians, area of sidewalk available for pedestrians, time-savings for the transport operators, time lost by normal traffic. However the only data that was available in this pilot was the time and date when the vehicles entered and left the LUPBs, which allowed to estimate the parking times, and consequently the number of vehicles that parked for more than 30 minutes (which are seen in this work as infractions).

The **time-horizon** used was 15 years, due to the lifespans of the technologies: the VDS solution has a 5 year lifespan and the APM solution has 7.5 years of lifespan, therefore the least common multiple between the two lifespans is 15 years. With this time-horizon it is assured that both technologies can be compared in equal terms.

In this analysis it will not be used the **residual value** of the equipment, which is defined in the "Guide to Cost-Benefit Analysis of investment projects" of the European Commission as "the present value at year *n* of the revenues, net of operating costs, that the project will be able to generate because of the remaining service potential of fixed assets whose economic life is not yet completely exhausted" (European Commission, 2008, pg. 40) because the lifespan of both types of technologies coincide with the end of time horizon.

The CBA will be done for a **single parking space** of a LUPB in order to analyse the two ITS solutions with dimensionless data, because each side of the avenue has a different number of parking spaces on the LUPBs (9 parking spaces in the East side and 8 on the West side).

When performing a CBA the objective is to maximize the benefits and minimize the costs. In the case of EMEL's pilot, when the **infractions** are regarded as benefits it may lead to the idea that the objective is to maximize the infractions, which is not true.

The mission of EMEL is to perform an effective monitoring and enforcement of the parking spaces in the city of Lisbon. Nonetheless, a minimum number of infractions is always expectable regardless the level of enforcement. Such infractions, if detected and fined, will generate a revenue stream that cannot be ignored. Instead it could be used by EMEL to improve its own mission. Following this assumption, the revenues can be considered as a financial benefit to EMEL and, therefore, the infractions are considered a benefit in the CBA presented in this work.

6.2 EVALUATION METHOD USED IN THIS DISSERTATION

The case study of this dissertation will be evaluated with a simplified version of the CBA suggested by the European Commission in the "Guide to Cost-Benefit Analysis of investment projects", due to: the small dimension of the project to be analysed; since there were some indirect impacts that were not possible to estimate (these data limitations are better explained in the sub-chapter 6.1); and because the analysis will be based on the financial perspective.

Therefore, the analysis will be a simplified CBA that will follow these steps:

1. Definition of the **objectives** and **project identification**;
2. **Financial analysis** using the DCF methodology and the suggested discount rate of 5%;
   a. Discount benefits and costs to obtain present values:
      i. $PV(B) = \sum_{t=0}^{n} \frac{B_t}{(1+s)^t}$
      ii. $PV(C) = \sum_{t=0}^{n} \frac{C_t}{(1+s)^t}$

Where **s** is the discount rate and **t** is the year.

   b. Compute the net present value of each alternative:
      i. $NPV = PV(B) - PV\ (C)$
3. **Sensitivity analysis** to identify the critical variables.

The step of economic analysis was not included because the CBA is done through financial perspective, and a risk analysis was not included since the case study of this dissertation has a lack of statistical data that is needed to proceed with an analysis of this type.

6.3 CHARACTERIZING THE LOADING/UNLOADING ACTIVITIES

To evaluate how the implementation of the ITS solutions influenced the activities of loading and unloading on the dedicated parking bays it were carried out two observation periods in the avenue. The first was on the week from the 21st to the 26th of November 2011, i.e., before the pilot project was implemented. And the second was carried out from the 20th of February 2012 until the 3rd of March 2012. Each period of observation was made by two observers, one on each side of the avenue, from

9:00 until 19:00 on weekdays (Monday to Friday) and from 9:00 to 13:00 on Saturdays. The objective was to characterize these activities in Guerra Junqueiro Avenue. The relevant characteristics were:

- **"Legal deliveries (<=30 min)"**: Loading or unloading activities that took less than or equal to 30 minutes, because this was the time limit set for the activities of loading and unloading;
- **"Illegal deliveries (> 30 min)"**: Loading or unloading activities that took more than 30 minutes;
- **"Deliveries outside LUPBs"**: Loading or unloading activities made outside LUPBs (sidewalks, crosswalks, double-parking or regular parking places);
- **"Deliveries on LUPBs"**: Loading or unloading activities made on LUPBs;
- **"Total deliveries"**: Total number of loading or unloading activities in the avenue;
- **"Private cars parked on LUPBs"**: Number of private cars parked on LUPBs;
- **"Total vehicles parked on LUPBs"**: Total number of vehicles parked on LUPBs.

From the observations done before the implementation of the pilot it was concluded that the **usual problems** that affected freight vehicles and the LUPBs were:

- Private cars parked on LUPBs – specially at the end of the afternoon, when parents come to pick up their children from school;
- Freight vehicles double parked or parked on sidewalks, crosswalks, or regular parking spaces – sometimes because the LUPBs where full, and others just because it was near to where they had to deliver goods;
- Abusive occupancy of the LUPBs by freight vehicles – more than 30 minutes;
- Heavy freight vehicles that occupy the whole LUPB – specially the ones that were delivering good to the supermarket.

These problems also correspond to the most common infringements that are committed in the avenue.

With the observations mentioned above, it was possible to draw the situation on Guerra Junqueiro Avenue before the pilot. The results of these observations were divided in “East” and “West”, to compare with the different ITS solutions that would be implemented on each side of the avenue:

Table 6.1 - Results of the observations of the east side of Guerra Junqueiro Avenue

East (VDS)

Type of data	Week	Saturday
Legal deliveries (<= 30 min)	24	2
Illegal deliveries (> 30 min)	5	2
Deliveries outside LUPBs	16	2
Deliveries on LUPBs	29	4
Total deliveries	45	6
Private cars parked on LUPBs	21	29
Total vehicles parked on LUPBs	50	33

Table 6.2 - Results of the observations of the west side of Guerra Junqueiro Avenue

West (APM)

Type of data	Week	Saturday
Legal deliveries (<= 30 min)	30	0
Illegal deliveries (> 30 min)	9	0
Deliveries outside LUPBs	8	2
Deliveries on LUPBs	39	0
Total deliveries	47	2
Private cars parked on LUPBs	29	33
Total vehicles parked on LUPBs	68	33

With this information generated by the period of observations in the Avenue we can conclude that there are more vehicles performing loading/unloading activities in the west LUPBs, which results in a higher number of road traffic offences: freight vehicles parking more than 30 minutes and private cars parked on the LUPBs. On Saturdays the Avenue is mostly used for normal parking, and that is confirmed by the few number of loading or unloading activities on both sides of the Guerra Junqueiro Avenue. One important characteristic of these activities is that t

here are many loading/unloading activities that are done outside these LUPBs: on east side are 35,5% of total; and on west side are 17% of total.

6.4 COSTS & BENEFITS DURING THE PILOT

6.4.1 TO-BE VDS

6.4.1.1 COSTS

According to the information that was collected in meetings with EMEL's personnel, the costs of this solution came from the acquisition of a total of **13 sensors** (each one costs $400€$[2]), although it was only needed 1 sensors per each parking place, which give us a total of 9 sensors ($9 \times 400{,}00€ = 3.600{,}00€$), it was needed to acquire 4 more ($4 \times 400{,}00€ = 1.600{,}00€$) because some were damaged (or malfunctioning) during the pilot and needed to be replaced.

It was also needed to buy all the **hardware and software** (gateways, solar panels and computer software) needed to link the sensors to the website and to the EMEL's OCC.

During the pilot there were costs with **human resources**: there was an average of 4 EMEL's agents responsible for the monitoring and enforcement of Guerra Junqueiro Avenue during these 15 weeks. These costs are explained on the Annex 2.

And finally, there are also **maintenance** costs of the LUPBs (cleaning, painting, etc.), which are $15{,}97€$[3] per year for each parking place. Since there are 9 parking places: $9 \times 15{,}97€ = 143{,}73€/year$

All these costs are presented below.

Table 6.3 - Costs of the VDS solution

Project Costs	Description	To-be VDS
Technology acquisition	9 Sensors: 400€ each	3.600,00 €
	4 Sensors (damaged): 400€ each	1.600,00 €
Communications	Hardware and Software	3.500,00 €
Human Resources	Enforcement	346,67 €
Maintenance	Cleaning, painting, etc. of the 9 LUPBs	143,73 €
Total of Costs		11.550,62 €

6.4.1.2 BENEFITS

With the implementation of this ITS solution it was expected that the enforcement process would be less dependent of human resources and more automatic, because it would rely on technology rather than on visual monitoring of the LUPBs by EMEL's agents.

Other expectation was that it would improve parking surveillance efficiency, because it can detect the vehicles that enter the dedicated parking bays on a 24/7 basis.

Despite these expectations, these are qualitative benefits that were not possible to monetize, therefore the benefits used to study the implementation of this ITS solution will be the benefits from EMEL's perspective, i.e., will be the money received by issuing the parking fines. The price of each parking fine would be of 60€.

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[2] This value was given to the author on a meeting on the 19th of December of 2012 on EMEL's headquarters with Óscar Rodrigues.

[3] This value was given to the author on a meeting on the 4th of April of 2013 on EMEL's headquarters with Nuno Sardinha.

If a private car was illegally parked on a LUPB this would also result on a parking fine for the driver of that vehicle, but since this type of parking fine can only be detected by the Parking Officers, this will not be a differentiating factor between the two ITS solutions, therefore the author will only consider the parking fines due to abusive occupancy of the LUPBs.

According to the second period of observations, i.e., during the pilot, there was an average of 8 parking fines per week due to abusive occupancy (more than 30 minutes), but the sensors detected a total of 937 metallic masses that were in the LUPBs more than 30 minutes during the 15 weeks of the pilot.

Table 6.4 - Summary of the data gathered by the observations on the VDS side of the Avenue

Illegal deliveries (> 30 min)	Week	Weekend
Before the pilot	5	2
During the pilot	6	2

Table 6.5 - Parking fines predicted from the observations and detected by the VDS during the pilot

	Predicted by Observations	Detected during pilot
Parking Fines during pilot	120 [4]	937
Parking fines (€)	7.200,00 €	56.220,00 €

The value of 937 parking fines is much higher than the 120 parking fines extrapolated from the observations data. The author can't explain this value (937), but maybe the pilot was made during an atypical period or the technology still has some problems on the detection of the metallic masses.

Since the values gathered by the observations made before and during the pilot are coherent, those are the number of parking fines that will be used in this study (120 parking fines during the pilot).

[4] With an average of 8 parking fines per week, and since the pilot occurred during 15 weeks:

$$8 \times 15 = 120 \; parking \; fines.$$

6.4.2 **TO-BE APM**

6.4.2.1 COSTS

The costs of this second ITS solution are similar to the other one, with just minor differences. All the information was also gathered in meetings with EMEL's personnel.

In this case it was needed to acquire **2 APM** to cover all the LUPBs of the west side of Guerra Junqueiro Avenue. The cost of each APM is 5.000,00€ but each one monitors a total of 20 parking places, and since there are 8 parking places on the LUPBs of the West side of the avenue, the author estimated that only a portion (8/40) of the APM would be associated to the pilot:

$$(5.000{,}00€ \times 2) \times \left(\frac{8}{40}\right) = 2.000{,}00€$$

The **hardware and software** needed for communications was more expensive (5.000€).

There were also costs with **human resources**, because in this solution the detection of infringements is the responsibility of the EMEL's agents. These are better explained on the Annex 2.

Finally, there were some costs related to the **maintenance** of the LUPBs, which are based on the same value given by EMEL: 15,97€ per year for each parking place.

The costs are presented below:

Table 6.6 - Costs of the APM solution

Project Costs	Description	To-be APM
Technology acquisition	2 Parking meters: 5000€ each (serving a total of 40 parking places, from which 8 are on LUPBs)	2.000,00 €
Communications	Hardware and Software	5.000,00 €
Human Resources	Enforcement	284,33 €
Maintenance	Cleaning, painting, etc. of the 8 LUPBs	127,76 €
Total of Costs		7.420,76 €

6.4.2.2 BENEFITS

The expected benefits of this solution were related to a higher vehicle rotation, which would represent an increase of parking place availability and also a reduction of the duration of freight activities. With the identification of the vehicles that were doing loading or unloading activities, it was also expected by EMEL to have a better control of these LUPBs which would mean a reduction of conflicts with other public space users.

Despite these expectations, there are qualitative benefits that were not possible to monetize, therefore the benefits used to study the implementation of this ITS solution will be the benefits from EMEL's perspective, i.e., will be the money received by issuing the parking fines. The price of each parking fine would be of 60€.

According to the second period of observations, i.e., during the pilot, there was an average of 5 parking fines per week due to abusive occupancy (more than 30 minutes), but the Parking Officers detected a total of 81 vehicles on LUPBs with an expired parking ticket during the 15 weeks of the pilot.

Table 6.7 - Summary of the data gathered by the observations on the APM side of the Avenue

Illegal deliveries (> 30 min)	Week	Weekend
Before the pilot	9	0
During the pilot	5	0

Table 6.8 - Parking fines predicted from the observations and detected by the Parking Officers during the pilot

	Predicted by Observations	Detected during pilot
Parking fines during pilot	75	81
Parking fines (€)	4.500,00 €	4.860,00 €

For the same reason stated before, the author will only consider the parking fines due to abusive occupancy (more than 30 minutes) of the LUPBs.

In this case the number of parking fines extrapolated by the observations and detected by the parking officers during the pilot are closer (75 and 81), but as a matter of coherence the author will use the number of parking fines extrapolated by the observations (75 parking fines during the pilot) in the study of the APM technology.

6.5 SIMPLIFIED COST-BENEFIT ANALYSIS

6.5.1 TO-BE VDS

6.5.1.1 VARIABLES

To do the Simplified CBA it was needed to define the value of a group of variables that will be described below.

The **time-horizon** that is used in this analysis is 15 years, because it is the minimum number of years with which we can compare both technologies, since the sensors have a 5 years lifespan (3 acquisitions) and the APM have 7,5 years (2 acquisitions).

The **rate of parking fines in the first year** and **parking fines in the first year** are directly related to the number of parking fines detected during the pilot. When the **rate of parking fines in the first year** is 100% it means that it is expected that the results of the pilot are repeated throughout the year.

The number of **parking fines in the first year** is a prediction of the numbers of the pilot for a 52 weeks period (1 year). Since this analysis will be done for a single parking place of the LUPBs the estimation of this variable was made like this:

- It were detected 120 parking fines during the pilot (15 weeks);
- With this average it is predicted to have 416 parking fines per year (52 weeks);
- Since we have 9 parking places, the number of parking fines for each parking place is 47.

The value used for the **discount rate** is 5,0%, as it was used in the Finish “Guidelines for the evaluation of ITS projects” (Kulmala *et al.*, 2002, pg. 45) and it is also the value suggested on the European Commission’s “Guide to Cost-Benefit Analysis of investment projects” (European Commision, 2008, pg. 18). But the value of the discount rate can change with the country of application, and in Canada it was used 7,5% on a highway project (Macário, 2013, pg. 13). The impact of the discount rate will be studied with a sensitivity analysis.

During the pilot there were some sensors that were damaged and needed to be replaced, therefore the author created a variable to study the impact of the number of **sensors damaged per year** in the results. The impact of this variable will also be studied with a sensitivity analysis.

With the introduction of an automatic process of detecting infringements, there is the possibility that the number of parking fines is reduced because the drivers are aware that the detection rate is higher, therefore they may be more careful. This possibility can be confirmed by the following examples: with the implementation of monitoring systems in a new area of Lisbon exploited by EMEL in 2012 the number of parking fines decreased 58% from the first year to the second year of implementation. The data is showed in the Table 6.9.

Table 6.9 - Evolution of parking fines in a new area of Lisbon exploited by EMEL[5]

	Jan	Feb	Mar	Apr	May	Jun
Parking fines 2012	79	348	333	220	146	95
Average 2012	204					
Parking fines 2013	79	135	92	3	118	83
Average 2013	85					
Reduction from 2012 to 2013	-58%					

And comparing the numbers of the west side of Guerra Junqueiro Avenue during the pilot (December 2011 – March 2012) with the numbers in the previous year (December 2010 – March 2011) it is possible to conclude that there has been a 57% reduction of the number of parking fines with the implementation of monitoring and enforcement systems.

Table 6.10 - Parking fines in the west side of Guerra Junqueiro Avenue[6]

	Dec	Jan	Feb	Mar	TOTAL	
2010/2011	35	38	54	60	187	Reduction
2011/2012	31	11	21	18	81	-57%

Therefore the variable "**reduction after the 1st year**" was created to simulate this reduction of the number of parking fines from the year of implementation (1st year) to the next. Since the value of this variable can change due to some characteristics of the area being studied, it will be performed a sensitivity analysis to assess its influence on the NPV of this alternative.

And to simulate this reduction of parking fines after the 2nd year of implementation it was created the variable "**reduction after the 2nd year**". Initially this variable is defined as 0%, but it will be performed a sensitivity analysis to understand how it will influence the NPV of this alternative.

In conclusion, the variables that were defined to proceed with the Simplified CBA are the following:

Table 6.11 - Variables used in the Simplified CBA for the To-be VDS alternative

Time-horizon	15 years
Rate of parking fines in the first year	100%
Parking fines in the first year	47
Discount rate (s)	5,0%
Sensors damaged per year	0
Reduction after the 1st year	57%
Reduction after the 2nd year	0%

[5] This information was given to the author on the 14th of August of 2013 by Nuno Sardinha of EMEL.
[6] This information was given to the author on the 14th of August of 2013 by Nuno Sardinha of EMEL.

6.5.1.2 SIMPLIFIED CBA

As it was explained before, the benefits taken into account in this analysis are the money received by EMEL by issuing parking fines. It was estimated that the average of parking fines is 47 per year, therefore, with the value of 60€ of each parking fine, the benefits in the first year are 2.820,00€. And in the following years is applied the reduction of parking fines that was defined on the variables "Reduction after the 1st year" and "Reduction after the 2nd year"

It was considered 4 types of costs: technology acquisition & implementation; communications; human resources; and maintenance.

Since this analysis is made for each parking place, the costs of technology acquisition & implementation are the price of a Vehicle Detection Sensor, i.e. 400€. The costs with communication for each parking place are a fraction (1/9th) of the total costs with communication presented on the chapter 6.4.1.1 ($3500 \div 9 = 388{,}89€$). The costs with human resources take into account the time that EMEL's parking officers spent issuing parking tickets and moving to the LUPB after receiving an alert of an infringement, but these costs are explained better in Annex 2. And finally, the maintenance costs of each parking place (cleaning, painting, etc.) are 15.97€ per year, as this was the value given by EMEL.

After having the benefits (B) and costs (C) listed and computed it is necessary to compute the present value (PV) of each year:

$$PV_t(B_t - C_t) = \frac{B_t - C_t}{(1+s)^t}$$

Where **s** is the discount rate and **t** is the year.

Finally, we can compute the net present value of the To-be VDS alternative:

$$NPV = \sum_{t=1}^{15} PV_t(B_t - C_t)$$

The results of this Simplified CBA are shown on the summary table below and the whole computed values can be seen on the next page.

Table 6.12 - Summary of Simplified CBA of the To-be VDS alternative

Time-horizon	15 years
Rate of parking fines in the first year	100%
Parking fines in the first year	47
Discount rate (s)	5,0%
Sensors damaged per year	0
Reduction after the 1st year	57%
Reduction after the 2nd year	0%
Total investment in the first year	789 €
Net Present Value (€/year*parking place)	**12.356 €**

Table 6.13 - Simplified CBA of the To-be VDS alternative

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Benefits															
Rate of parking fines	100%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%
Parking fines per year	47	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Parking fines (€)	2.820,00 €	1.200,00 €	1.200,00 €	1.200,00 €	1.200,00 €	1.200,00 €	1.200,00 €	1.200,00 €	1.200,00 €	1.200,00 €	1.200,00 €	1.200,00 €	1.200,00 €	1.200,00 €	1.200,00 €
Costs															
Technology acquisition & Implementation	400,00 €	0,00 €	0,00 €	0,00 €	0,00 €	400,00 €	0,00 €	0,00 €	0,00 €	0,00 €	400,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Communications	388,89 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Human Resources	38,52 €	16,56 €	16,56 €	16,56 €	16,56 €	16,56 €	16,56 €	16,56 €	16,56 €	16,56 €	16,56 €	16,56 €	16,56 €	16,56 €	16,56 €
Maintenance	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €
Total Costs	843,38 €	32,53 €	32,53 €	32,53 €	32,53 €	432,53 €	32,53 €	32,53 €	32,53 €	32,53 €	432,53 €	32,53 €	32,53 €	32,53 €	32,53 €
Benefits-Costs	1.976,62 €	1.167,47 €	1.167,47 €	1.167,47 €	1.167,47 €	767,47 €	1.167,47 €	1.167,47 €	1.167,47 €	1.167,47 €	767,47 €	1.167,47 €	1.167,47 €	1.167,47 €	1.167,47 €
Discount rate	5,0%														
Present Value (Benefits-Costs)	1.882,50 €	1.058,93 €	1.008,50 €	960,48 €	914,74 €	572,70 €	829,70 €	790,19 €	752,56 €	716,72 €	448,72 €	650,09 €	619,13 €	589,65 €	561,57 €
Net Present Value	12.356,18 €														

6.5.1.3 Sensitivity Analysis: Discount Rate

The discount rate is an important variable since it accompanies the economic evolution. Given that this is a financial analysis, this variable becomes relevant to be analysed through a sensitivity analysis.

The results of this analysis show that reducing the discount rate to half (to 2,5%) will cause a 18,1% increase of the NPV, and if the discount rate increases 50% (to 7,5%) the NPV will decrease around 14,1%. We can conclude that a decrease of the discount rate is more significant than an increase of its value, but overall this variable does not have a great influence on the NPV of the To-be VDS alternative. Therefore the use of a discount rate of 5,0% is acceptable in this study.

Table 6.14 - Sensitivity analysis of the To-be VDS alternative: discount rate

	s=2,5%	s=4,0%	s=5,0%	s=6,0%	s=7,5%
Net Present Value	14.594 €	13.182 €	12.356 €	11.609 €	10.618 €
Change	18,1%	6,7%	0,0%	-6,0%	-14,1%

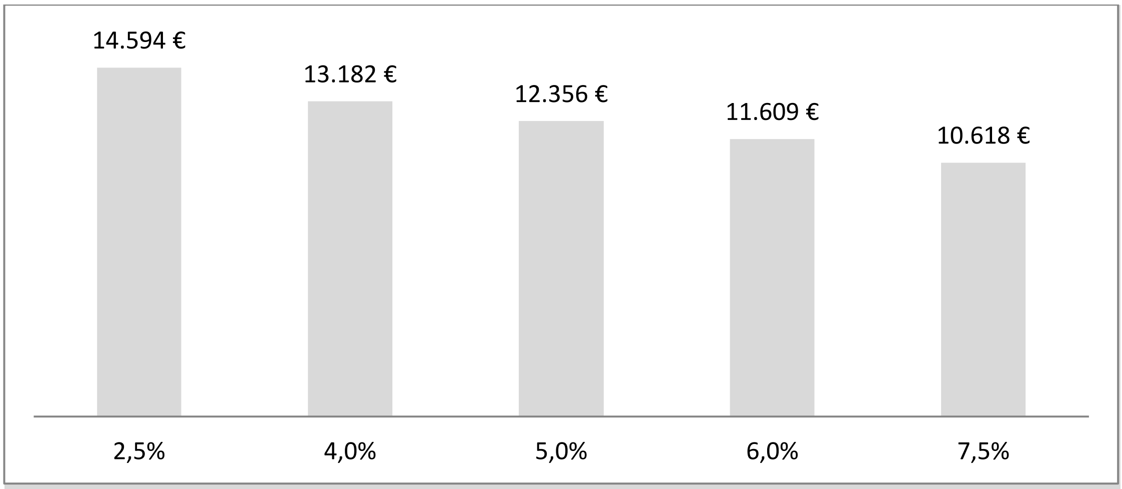

Figure 6.1 - Sensitivity analysis of the To-be VDS alternative: discount rate

6.5.1.4 Sensitivity Analysis: Sensors damaged per year

The number of sensors damaged per year has an impact on the NPV of this alternative, because if we have to buy more sensors to replace the damaged ones this will increase the costs, therefore reducing the NPV.

Following the results of the pilot, we have to replace 4 sensors per each 4 months, which gives a total of 12 sensors damaged per year. If we consider the results of this sensitivity analysis, with 12 sensors damaged per year the NPV of the To-be VDS alternative is reduced 5.000€ to a total of 7.353€ after 15 years of implementation, which means a 40% reduction of the NPV.

Table 6.15 - Sensitivity analysis of the To-be VDS alternative: Sensors damaged per year

No. of Sensors	0	3	6	9	12	24	28
Net Present Value	12.356 €	11.505 €	10.121 €	8.737 €	7.353 €	1.817 €	-28 €
Change of NPV	0%	-7%	-18%	-29%	-40%	-85%	-100%

We can conclude that 28 is the number of sensors damaged (which means an average of around 3 sensors replaced on each parking space) that makes the To-be VDS alternative unviable, because the NPV decreases around 100%.

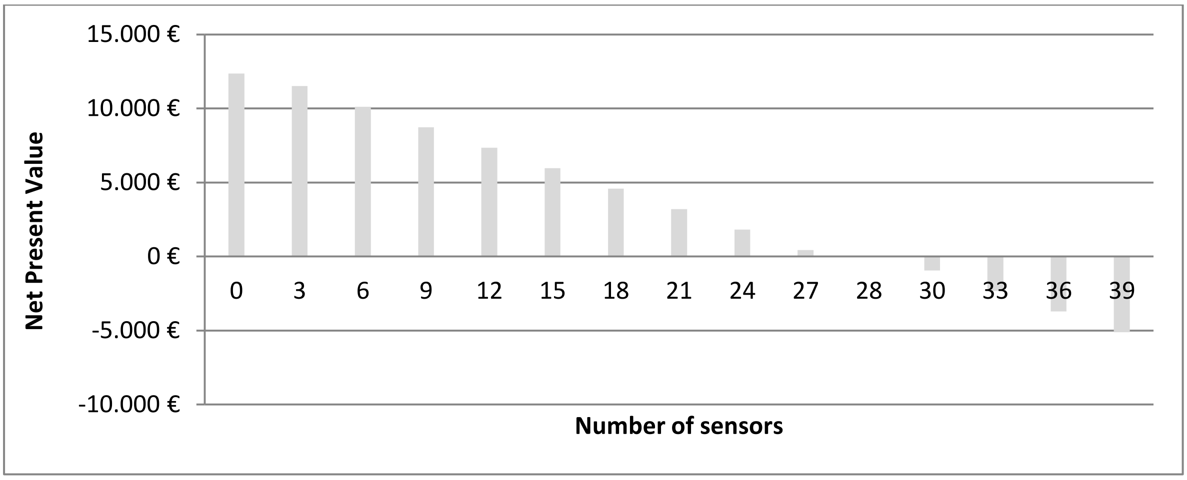

Figure 6.2 – Sensitivity analysis of the To-be VDS alternative: Sensors damaged per year

We can conclude that this variable has a great influence in the NPV, because if the results of the pilot are repeated on the next 15 years, i.e. 12 sensors are damaged on each year, the NPV decreases 40%, but on the other hand throughout the 15 years the technology of the sensors may be improved and the sensors may become more resistant, which can decrease the number of sensors damaged.

The author will use the number of 6 for the variable **sensors damaged per year**, because he wants to simulate a decrease of the number of sensors damaged per year throughout the 15 year of this analysis – if we had 12 sensors damaged on the first year, on the next years this number would decrease making the average of 6 per year on the 15 years.

6.5.1.5 *SENSITIVITY ANALYSIS: REDUCTION OF PARKING FINES AFTER THE FIRST YEAR AND AFTER THE SECOND YEAR*

To assess the importance of the two variables that simulate the reduction of parking fines over time it was used a 3D surface graph. As the two variables are studied at the same time it is possible to evaluate the best case scenario and also the worst case scenario.

If the number of parking fines stays the same over 15 years (47 parking fines, which means an average of almost 1 parking fine per day) we will have a NPV of 27.421€.

If we reduce the number of parking fines **after the 1st year** 20%, and keeping it for the next 14 years (the **other variable is 0%**), the NPV decreases around 20,4% to 21.838€. But if we do the opposite, fixing the **reduction after the 1st year** at 0% and increasing the variable **reduction after the 2nd year** to 20%, the NPV will decrease 57,6% to the value of 11.631€. We can conclude that the variable **reduction after the 2nd year** has a greater impact on the NPV.

In the worst case scenario, with the **reduction after the 1st year** at 95% and **reduction after the 2nd year** at 25% the NPV is still positive (1.969€), this means that this alternative is worthwhile.

Table 6.16 - Sensitivity analysis of the To-be VDS alternative: Reduction of parking fines over time

NPV		Reduction after the 2nd year					
		0%	5%	10%	15%	20%	25%
Reduction after the 1st year	95%	2.878 €	2.473 €	2.230 €	2.101 €	2.015 €	1.969 €
	80%	6.783 €	5.385 €	4.551 €	3.931 €	3.478 €	3.184 €
	57%	12.356 €	9.888 €	8.068 €	6.753 €	5.888 €	5.136 €
	40%	16.820 €	13.259 €	10.660 €	8.903 €	7.582 €	6.558 €
	20%	21.838 €	17.194 €	13.672 €	11.337 €	9.589 €	8.261 €
	0%	27.421 €	21.048 €	16.863 €	13.863 €	11.631 €	10.058 €

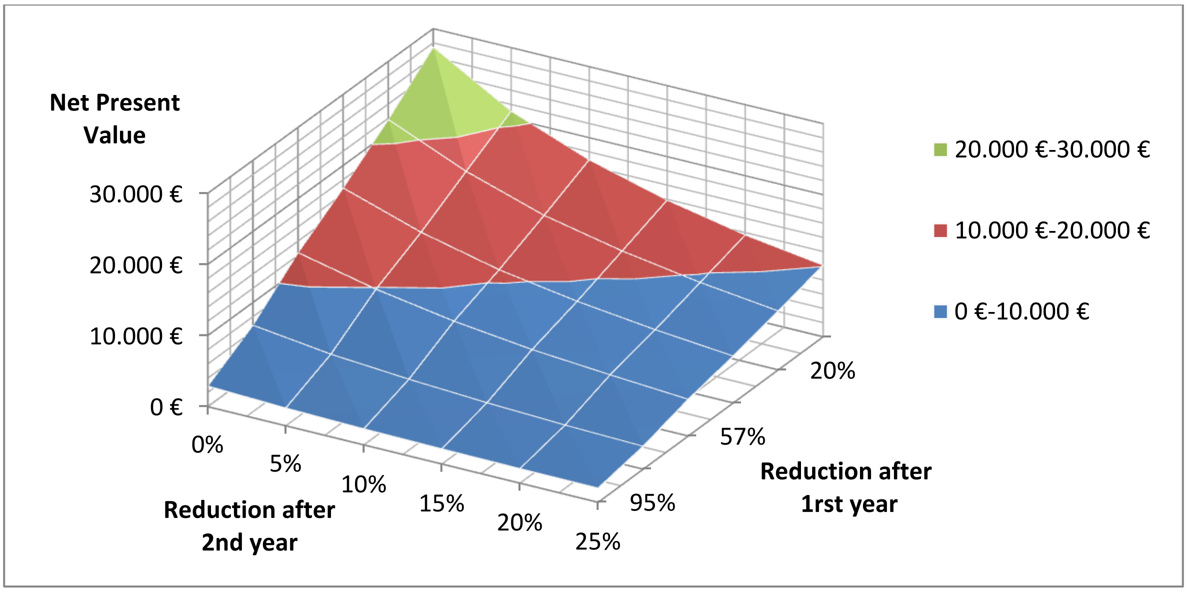

Figure 6.3 – Sensitivity analysis of the To-be VDS alternative: Reduction of parking fines over time

6.5.1.6 *PREDICTION FOR ALL LUPBS IN LISBON*

According to EMEL there are 1577 LUPBs in Lisbon, therefore a prediction can be made based on the results of the Simplified CBA that were presented before.

It were considered the results of the sensitivity analysis which led the author to define some variables with different values than the ones used before, with the objective of better simulating what would happen if we would implement the To-be VDS alternative.

The **number of sensors damaged per year** was defined as 6 because the author believes that the pilot's results (12 sensors damaged per year) would decrease over time, and the **reduction after the 2nd year** was fixed at 5% to simulate a reduction of parking fines over time.

This prediction gives a Net Present Value of 12.0 M€ after 15 years of operation, with 1.6 M€ that need to be invested in the first year to implement this technologies on all LUPBs exploited by EMEL in Lisbon.

Table 6.17 - Prediction for all LUPBs in Lisbon - VDS

Time-horizon	15 years
Rate of parking fines in the first year	100%
Parking fines in the first year	74.119
Discount rate (s)	5%
Sensors damaged per year	6
Reduction after the 1st year	57%
Reduction after the 2nd year	5%
Total investment in the first year	1.664.611 €
Net Present Value	**12.067.853 €**

6.5.1.7 *CRITICAL NUMBER OF PARKING FINES*

This critical number of parking fines is the lowest number of parking fines that gives a positive NPV at the end of the 15 years. Using the values of the variables defined for the prediction to all LUPBs in Lisbon, the number of parking fines has to decrease to 31% of the prediction made from the results of the pilot (15 parking fines) for the NPV to become the lowest positive possible.

Table 6.18 - NPV of the scenario with the critical number of parking fines

Rate of parking fines in the first year	30,0%	31,0%
Parking fines in the first year	14	15
Discount rate (s)	5,0%	5,0%
Sensors damaged per year	6	6
Reduction after the 1st year	57%	57%
Reduction after the 2nd year	5,0%	5,0%
Total investment in the first year	1.056 €	1.056 €
Net Present Value (€/year*parking place)	-97,17 €	94,45 €
NPV prediction for all LUPBs in Lisbon	**-153.234 €**	**148.945,40 €**

6.5.2 TO-BE APM

6.5.2.1 VARIABLES

To do the Simplified CBA it was needed to define the value of a group of variables that will be described below.

The **time-horizon** that is used in this analysis is 15 years, because it the minimum number of years with which we can compare both technologies, since the sensors have a 5 years lifespan (3 acquisitions) and the APM have 7,5 years (2 acquisitions).

The **rate of parking fines in the first year** and **parking fines in the first year** are directly related to the number of parking fines detected during the pilot. When the **rate of parking fines in the first year** is 100% it means that it is expected that the results of the pilot are repeated throughout the year.

The number of **parking fines in the first year** is a prediction of the numbers of the pilot for a 52 weeks period (1 year). Since this analysis will be done for a single parking place of the LUPBs the estimation of this variable was made like this:

- It were detected 75 parking fines during the pilot (15 weeks);
- With this average it is predicted to have 260 parking fines per year (52 weeks);
- Since we have 8 parking places, the number of parking fines for each parking place is 33.

The value used for the **discount rate** is 5,0%, and this value was explained before on the To-be VDS alternative.

It will also be used the variable "**reduction after the 1st year**" to simulate the reduction of the number of parking fines after the first year of operation of the To-be APM alternative.

To simulate a reduction of parking fines after the 2nd year of implementation it was created the variable "**reduction after the 2nd year**". Initially this variable is defined as 0%, but it will be performed a sensitivity analysis to understand how it will influence the NPV of this alternative.

In conclusions, the variables that were defined to proceed with the Simplified CBA are the following:

Table 6.19 - Variables used in the Simplified CBA for the To-be APM alternative

Time-horizon	15 years
Infraction rate in the first year	100%
Infractions in the first year	33
Discount rate (s)	5,0%
Reduction after the 1st year	57%
Reduction after the 2nd year	0%

6.5.2.2 *SIMPLIFIED CBA*

As it was explained before, the benefits taken into account in this analysis are the money received by EMEL by issuing parking fines. It was estimated that the average of parking fines is 33 per year, therefore, with the value of 60€ of each parking fine, the benefits in the first year are 1.980,00€. And in the following years is applied the reduction of parking fines that was defined on the variables "Reduction after the 1st year" and "Reduction after the 2nd year"

It was considered 4 types of costs: technology acquisition & implementation; communications; human resources; and maintenance.

Since this analysis is made for each parking place, the costs of technology acquisition & implementation are a fraction of the total cost of the two Adapted Parking Meters (5000€ each). As it was explained before in the chapter 6.4.2.1, the two APMs serve a total of 40 parking places, and we have 8 parking places on LUPBs, which gives a cost with APM of 2.000€ for those 8 parking places. To estimate the cost for each parking place we have to divide these 2.000€ for 8, which gives us 250€. This cost we have to repeat every 7.5 years because that is the lifespan of the technology. The costs with communication for each parking place are a fraction (1/8th) of the total costs with communication presented on the chapter 6.4.2.1 ($5000 \div 8 = 625{,}00€$). The costs with human resources take into account the time that EMEL's parking officers spent issuing parking tickets and monitoring the LUPBs of the avenue, but these costs are explained better in Annex 2. And finally, the maintenance costs of each parking place (cleaning, painting, etc.) are 15.97€ per year, as this was the value given by EMEL.

After having the benefits (B) and costs (C) listed and computed it is necessary to compute the present value (PV) of each year:

$$PV_t(B_t - C_t) = \frac{B_t - C_t}{(1+s)^t}$$

Where **s** is the discount rate and **t** is the year.

Finally, we can compute the net present value of the To-be VDS alternative:

$$NPV = \sum_{t=1}^{15} PV_t(B_t - C_t)$$

The results of this Simplified CBA are shown on the summary table below and the whole computed values can be seen on the next page.

Table 6.20 - Summary of Simplified CBA of the To-be APM alternative

Time-horizon	15 years
Infraction rate in the first year	100%
Infractions in the first year	33
Discount rate (s)	5,0%
Reduction after the 1rst year	57%
Reduction after the 2nd year	0%
Total investment in the first year (€/parking place)	875 €
Net Present Value (€/year*parking place)	**8.340 €**

Table 6.21 - Simplified CBA of the To-be APM alternative

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Benefits															
Rate of parking fines	100%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%
Parking Fines per year	33	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Parking Fines (€)	1.980,00 €	840,00 €	840,00 €	840,00 €	840,00 €	840,00 €	840,00 €	840,00 €	840,00 €	840,00 €	840,00 €	840,00 €	840,00 €	840,00 €	840,00 €
Costs															
Technology acquisition & Implementation	250,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	250,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Communications	625,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Human Resources	35,54 €	27,82 €	27,82 €	27,82 €	27,82 €	27,82 €	27,82 €	27,82 €	27,82 €	27,82 €	27,82 €	27,82 €	27,82 €	27,82 €	27,82 €
Maintenance	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €	15,97 €
Total Costs	926,51 €	43,79 €	43,79 €	43,79 €	43,79 €	43,79 €	43,79 €	293,79 €	43,79 €	43,79 €	43,79 €	43,79 €	43,79 €	43,79 €	43,79 €
Benefits-Costs	1.053,49 €	796,21 €	796,21 €	796,21 €	796,21 €	796,21 €	796,21 €	546,21 €	796,21 €	796,21 €	796,21 €	796,21 €	796,21 €	796,21 €	796,21 €
Discount rate	5,0%														
Present Value (Benefits - Costs)	1.003,32 €	722,18 €	687,79 €	655,04 €	623,85 €	594,14 €	565,85 €	369,69 €	513,24 €	488,80 €	465,53 €	443,36 €	422,25 €	402,14 €	382,99 €
Net Present Value	8.340,18 €														

6.5.2.3 *SENSITIVITY ANALYSIS: DISCOUNT RATE*

The discount rate is an important variable since it accompanies the economic evolution. Given that this is a financial analysis, this variable becomes relevant to be analysed through a sensitivity analysis.

The results of this analysis show that reducing the discount rate to half (to 2,5%) will cause a 18,7% increase of the NPV, and if the discount rate increases 50% (to 7,5%) the NPV will decrease around 14,5%. We can conclude that a decrease of the discount rate is more significant than an increase of its value, but overall this variable does not have a great influence on the NPV of the To-be APM alternative. Therefore the use of a discount rate of 5,0% is acceptable in this study.

Table 6.22 - Sensitivity analysis of the To-be APM alternative: discount rate

	s=2,5%	s=4,0%	s=5,0%	s=6,0%	s=7,5%
Net Present Value	9.904 €	8.917 €	8.340 €	7.819 €	7.127 €
Change	18,7%	6,9%	0,0%	-6,3%	-14,5%

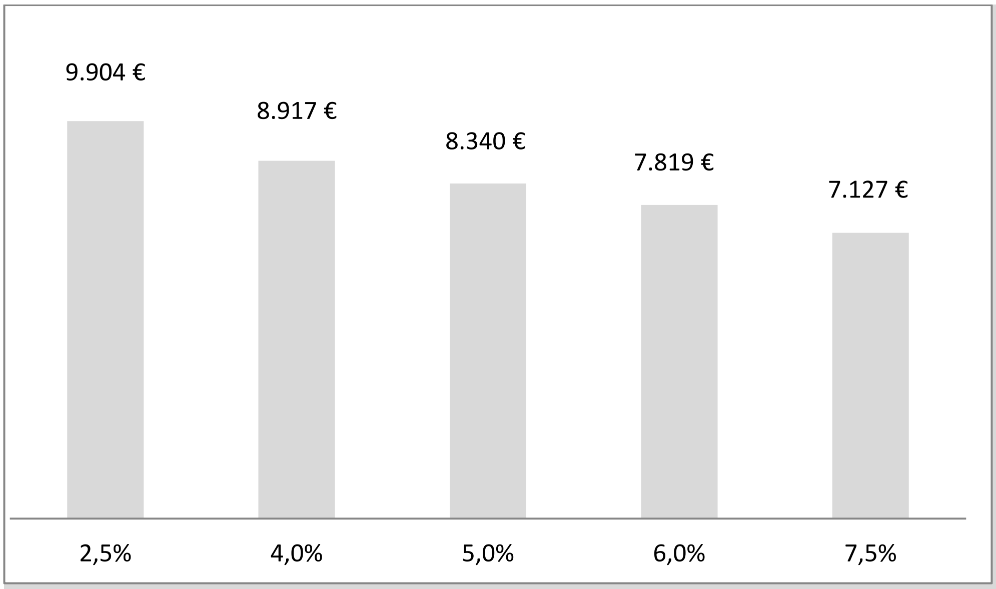

Figure 6.4 - Sensitivity analysis of the To-be APM alternative: discount rate

6.5.2.4 *SENSITIVITY ANALYSIS: REDUCTION OF PARKING FINES AFTER THE FIRST YEAR AND AFTER THE SECOND YEAR*

To assess the importance of the two variables that simulate the reduction of parking fines over time it was used a 3D surface graph. As the two variables are studied at the same time it is possible to evaluate the best case scenario and also the worst case scenario.

If the number of parking fines stays the same over 15 years (33 parking fines) we will have a NPV of 19.015€.

If we reduce 20% the number of parking fines **after the 1st year**, and keeping it for the next 14 years (the **other variable is 0%**), the NPV decreases around 21% to 15.081€. But if we do the opposite, fixing the **reduction after the 1st year** at 0% and increasing the variable **reduction after the 2nd year** to 20%, the NPV will decrease 58% to the value of 7.911€. We can conclude that the variable **reduction after the 2nd year** has a greater impact on the NPV, so it is in this one that we have to take more time on its calibration if we want to simulate what would happen in reality with the implementation of the To-be APM alternative.

In the worst case scenario, with the **reduction after the 1st year** at 95% and **reduction after the 2nd year** at 25% the NPV is still positive (1.146€), this means that this alternative is worthwhile.

Table 6.23 - Sensitivity analysis of the To-be APM alternative: Reduction of parking fines over time

NPV		Reduction after the 2nd year					
		0%	5%	10%	15%	20%	25%
Reduction after the 1rst year	95%	1.601 €	1.478 €	1.285 €	1.194 €	1.195 €	1.146 €
	80%	4.410 €	3.557 €	2.925 €	2.469 €	2.247 €	1.982 €
	57%	8.340 €	6.680 €	5.447 €	4.495 €	3.789 €	3.329 €
	40%	11.712 €	9.096 €	7.269 €	6.020 €	5.104 €	4.389 €
	20%	15.081 €	11.932 €	9.506 €	7.754 €	6.468 €	5.581 €
	0%	19.015 €	14.616 €	11.685 €	9.445 €	7.911 €	6.864 €

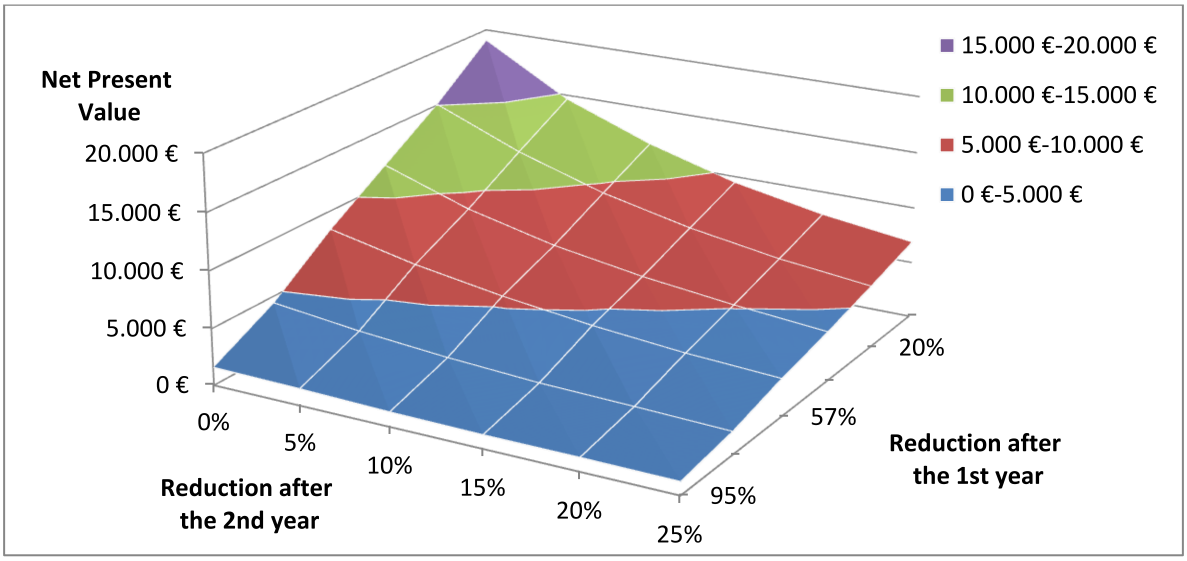

Figure 6.5 - Sensitivity analysis of the To-be APM alternative: Reduction of parking fines over time

6.5.2.5 PREDICTION FOR ALL LUPBS IN LISBON

According to EMEL there are 1577 LUPBs in Lisbon, therefore a prediction can be made based on the results of the Simplified CBA that were presented before.

In this alternative it were also considered the results of the sensitivity analysis, which led the author to define the variable **reduction after the 2nd year** to 5%, in order to simulate a reduction of parking fines over time.

This prediction gives a Net Present Value of around 10.7 M€ after 15 years of the operation, with almost 1.4 M€ that need to be invested in the first year to implement this technologies on all LUPBs exploited by EMEL in Lisbon.

Table 6.24 - Prediction for all LUPBs in Lisbon - APM

Time-horizon	15 years
Infraction rate in the first year	100%
Infractions in the first year	52.041
Discount rate (s)	5,0%
Reduction after the 1st year	57%
Reduction after the 2nd year	5%
Total investment in the first year (€)	1.379.875 €
Net Present Value (€)	**10.534.649 €**

6.5.2.6 CRITICAL NUMBER OF PARKING FINES

As it was explained when studying the To-be VDS alternative, the critical number of parking fines is the one that gives the lowest positive NPV. Using the values of the variables defined for the prediction to all LUPBs in Lisbon, the number of parking fines has to decrease to 11% of the prediction made from the results of the pilot (4 parking fines) for the NPV to become the lowest positive possible.

Table 6.25 - NPV of the scenario with the critical number of parking fines

Rate of parking fines in the first year	12,0%	14,0%
Parking fines in the first year	4	5
Discount rate (s)	5,0%	5,0%
Reduction after the 1st year	57,0%	57,0%
Reduction after the 2nd year	5%	5%
Total investment in the first year	875,00 €	875 €
Net Present Value (€/year*parking place)	-134 €	13 €
NPV prediction for all LUPBs in Lisbon	**-211.888€**	**19.983 €**

6.6 CONCLUSIONS OF THE CHAPTER

The To-be VDS alternative had a higher number of cases of abusive occupancy on Guerra Junqueiro Avenue during the pilot than the To-be APM alternative, but both ITS solutions have enough benefits to overcome the costs of investment already on the first year. And both have a positive NPV at the end of the time-horizon of the analysis, which makes both alternatives worthwhile.

Table 6.26 - Comparison of both alternatives before and after taking into account the reduction of parking fines after the 2nd year

	VDS	APM
Investment on the first year before reduction of parking fines after the 2nd year	789 €	875 €
NPV before reduction of parking fines after the 2nd year	12.356 €	8.340 €
Investment on the first year after reduction of parking fines after the 2nd year	1.056 €	875 €
NPV after reduction of parking fines after the 2nd year	9.888 €	6.680 €

Before taking into account a reduction of parking fines after the 2nd year, the To-be VDS alternative had a higher NPV than the To-be APM.

In the sensitivity analysis, the variable **reduction after the 2nd year** was considered the most relevant variable in this study. Therefore we have to take into account the results of the Simplified CBA that used this variable with the value of 5%, which are lower for both alternatives.

7 CONCLUSIONS

Urban areas have large populations that share its space and infrastructure for their daily life and for their mobility and for the mobility of goods. There is a high demand for transport within these areas since it is vital for the economic activities and daily life of its citizens. This space limitation is often the cause of major problems in providing freight transport services, which can lead to a loss of the efficiency of urban freight transport operations. The authors Allen & Eichhorn (Allen & Eichhorn, 2007) concluded that there are problems associated with City Logistics (CL), such as those related to loading/unloading regulations, fines, lack of unloading space, and handling problems.

Thus not being developed to the same extent as for passenger transport, urban authorities have begun to give a greater importance to urban freight transport measures, which can increase its efficiency and sustainability.

There are several definitions of CL in the scientific literature, but in this work it was chosen the one (from the author Stathopoulos *et al.*) that better describes the author's understanding of the City Logistics concept.

The European Union and the European Commission are aware of the importance of CL and its challenges, therefore they have funded several research activities in the area of transport in order to test new and innovative approaches to deal with the problems of CL. The author is aware that there were other research projects that were funded by the European Commission under the 7th FP, but it is the author's opinion that the examples presented give a wide overview of the possible approaches to overcome the problems of CL.

There are several different CL measures that are used to improve the logistics of urban freight transport, and they can be organized according to the following five categories: public infrastructure, land use management, access restrictions, traffic management, and enforcement and promotion. These categories include various options that can be considered by the municipal authorities with the purpose of improving CL. Whether it is a technological solution or a change in the regulations that lead to the desired changes in the drivers and citizens' behaviour, it appears to be very important to include all stakeholders of CL in the planning process. A positive debate between all stakeholders, where they state their needs and preferences, seems to generate higher acceptance rates among them and can provide a solution that satisfies everyone.

All five categories of CL measures presented provide important and useful measures to improve the efficiency of CL activities in urban areas, but according to the characteristics of the city some measures should be more appropriate than others. Therefore, it relies on the municipal authorities (or the relevant entities that regulate the CL activities) to choose the measures that better adapt to the dynamics of the city where they want to implement, in order to provide the best results possible.

There is the need to keep pace with the technological advances to allow using these in the planning of new logistic solutions. With the internet as a source of real-time information that can be accessed by almost everyone with a portable device, and the wireless communications devices that now exist, it is possible to design a system that monitors and controls several activities that are occurring at the same time in a whole city. These new systems can provide great efficiency gains of the monitoring and enforcement activities. Since they are less reliable on human resources, they make the process more automatic, which could result in lower costs in the long-haul.

Urban authorities implement CL measures with the objective of reducing the negative effects of urban freight delivery operations for its cities. Another objective of the municipalities is to prevent non-allowed freight transport operations that are forbidden by law, and they try to control these activities and its restrictions by enforcement activities, which are traditionally costly because are highly dependent on human resources. However, great efficiency gains can be obtained with the application of technology, which is where the importance of ITS arises. Significant advances have been made in the area of ITS applications, which can be used to perform a wide range of functions, and one of which is in the enforcement of CL.

When evaluating ITS projects, whether it is a private company or a public authority, the most popular evaluation method, despite having some limitations, is the Cost-Benefit Analysis (CBA). Basically a CBA is an overview of all the pros (benefits) and cons (costs) of a project or policy option. These costs and benefits are as much as possible quantified and expressed in monetary terms. Costs and benefits that occur in different years are discounted and presented as so called net present values (NPV). Final results are often presented in summarizing indicators, such as the difference between costs and benefits, the return on investment, and the benefit-cost ratio. This evaluation method can be used as a stand-alone quantitative method, or within a quantitative and qualitative framework, or even combined with Multi-Criteria Analysis (MCA).

Other methods of evaluation commonly used to assess the implementation of ITS are the Cost-Efficiency Analysis (CEA) and the MCA. However, according to the European Commission, “these approaches [CEA and MCA] cannot be seen as substitutes for CBA but rather as complements for special reasons, or as a rough approximation when actual CBA is impossible” (European Commission, 2008, p. 68).

The case study of this work was a pilot project that started in 2011 and it was the Portuguese participation on the project European project STRAIGHTSOL. The project was implemented in Guerra Junqueiro Avenue in Lisbon. The entities responsible for this pilot were the municipal company EMEL and the university Instituto Superior Técnico. It ran from December 2011 until March 2012, and the objective was to help choosing the right technology for controlling and monitoring loading and unloading activities on the whole city, and to provide evidence and the grounds for developing the Municipal Regulation on loading and unloading operations. With that objective in mind, it were tested two types of technologies, one on each side of the avenue: floor sensors that can identify the entrance or exit of a vehicle on the LUPB; and an adapted parking meter that issues a parking ticket that can only be used for loading and unloading activities.

It was necessary to draw a profile of these activities on the avenue before the pilot, so there was scheduled a period of two weeks of observations on-site, during November of 2011. On the first week there were a couple of unusual business days since there was a strike and a national holiday, and the result was that there was only the data of the second week available. This situation could have caused that the profile of the activities in the avenue before the pilot was not very accurate. During the implementation of the pilot there were two weeks of observations in the avenue, and these provided the data needed to draw the profile of the activities while the technologies were active.

During the implementation of both technologies on the pilot project in Lisbon, it were encountered some limitations and weaknesses. The first limitation was the type of data given by the solution with the sensors. In the first month of the pilot the sensors were not well calibrated to detect the presence of a vehicle. The temperature and humidity had a great influence on the magnetic field that was measured by the sensors, which resulted on hundreds of data of parking times that lasted 3 or 4 seconds (the difference between the time of entrance and exit of a vehicle). This was then changed and the detection turned out to be more accurate, although some of the “3 second parking” still appeared on the data. One major problem during the pilot was vandalism. The drivers and shopkeepers noticed the sensors, which were on the ground of the LUPBs, and some of them were not satisfied when they knew that their actions were being monitored. The result was that it were needed to be installed an additional 4 sensors during the pilot, because 4 sensors were damaged during that period. And the last problem was the batteries of the sensors, because some of them only lasted 1 month. As for the technology of the adapted parking meters, the main problem was that only a few deliveries were recorded on these machines. According to the data recorded by this technology only an average of 2 cards were used per day.

This work faced some problems in obtaining data regarding the impacts that could result from EMEL’s implementation of technology to ease the monitoring and enforcement of parking. The only data that was available was the time and date when the vehicles entered and left the LUPBs, which allowed to estimate the parking times, and consequently the number of vehicles that parked for more than 30 minutes (which are seen in this work as infractions).

Since there were data limitations, the case study of this dissertation was evaluated with a simplified version of the CBA suggested by the European Commission in the “Guide to Cost-Benefit Analysis of investment projects” (European Commission, 2008).

The methodology of CBA was used to study the implementation of both types of technology on the pilot project in Lisbon, and its results were used to compare both technologies.

Table 7.1 - Results of the Simplified CBA before after taking into account the reduction of parking fines after the 2nd year

	To-be VDS before reduction of parking fines after the 2nd year	To-be APM before reduction of parking fines after the 2nd year
Time-horizon	15 years	15 years
Rate of parking fines in the first year	100%	100%
Parking fines in the first year	47	33
Total investment in the first year	789 €	875 €
Net Present Value	12.356 €	8.340 €
NPV prediction for all LUPBs in Lisbon	19.485.412 €	13.152.180 €

The results of the Simplified CBA show that the To-be VDS alternative gives a higher NPV than the To-be APM alternative. But both ITS solutions pay the investment at the end of the first year of implementation, and both give a positive NPV at the end of the 15 years.

Table 7.2 - Results of the Simplified CBA using a reduction of parking fines after the 2nd year

	To-be VDS using a reduction of parking fines after the 2nd year	To-be APM using a reduction of parking fines after the 2nd year
Time-horizon	15 years	15 years
Rate of parking fines in the first year	100%	100%
Parking fines in the first year	47	33
Total investment in the first year	1.056 €	875 €
Net Present Value	9.888 €	6.680 €
NPV prediction for all LUPBs in Lisbon	15.593.317 €	10.534.649 €

With the sensitivity analysis we can conclude that the variable with greater influence on the NPV of both ITS solutions is the reduction (of parking fines) after the second year of implementation, and the discount rate of 5,0% can be used in this analysis. The results of the Simplified CBA using a reduction of 5% of the parking fines after the 2nd year show that the NPV of both alternatives is much closer than before.

But to compare both alternatives we have to fix the number of parking fines and then compare the NPV given by the analysis of ITS solutions:

Table 7.3 - Results of the Simplified CBA with the same number of parking fines

	To-be VDS	To-be APM
Time-horizon	15 years	15 years
Rate of parking fines in the first year	100%	142%
Parking fines in the first year	47	47
Total investment in the first year	1.056 €	875 €
Net Present Value	9.888 €	10.019 €
NPV prediction for all LUPBs in Lisbon	15.593.317 €	15.799.420 €

We can conclude that with the same number of parking fines, the To-be APM alternative is the one that has a higher NPV after the 15 years. This result is due to the fewer operation costs that this alternative has, when compared to the To-be VDS alternative.

The same conclusion can be drawn when analyzing the critical number of parking fines of both alternatives:

Table 7.4 - Critical number of parking fines of both ITS solutions

	Critical number of parking fines of To-be VDS	Critical number of parking fines of To-be APM	To-be APM with the same number of parking fines
Time-horizon	15 years	15 years	15 years
Rate of parking fines in the first year	31%	11%	45%
Parking fines in the first year	15	4	15
Total investment in the first year	1.056 €	875 €	875 €
Net Present Value	94 €	13 €	2.406 €
NPV prediction for all LUPBs in Lisbon	148.945 €	19.983 €	3.794.893 €

Since the critical number of parking fines of the To-be APM alternative is lower than the other ITS solution, it is expected that with the same number of parking fines the alternative of the APMs has the higher NPV at the end of the time-horizon of the analysis. This means that this alternative needs a lower investment at the first year and it presents a fewer risk of investment, since it needs less parking fines per year to pay the initial investment costs.

It is the author's opinion that the decision between these two ITS solutions should not only be focused on the NPV because the alternatives have different strengths and weaknesses.

The solution with the VDSs still has some errors on detecting the presence of the vehicle, but it can monitor the activities on the LUPBs continuously. The problems with this solution are: the actual lifespan because it still presents some problems with the batteries and is very vulnerable to vandalism acts, and also the problem of not being able to identify the vehicles that park on the LUPBs.

The other solution, with the APMs, is more dependent on human resources and goes against one of the objectives: reduce costs with human resources and create a more automatic enforcement system. But has the advantage of identifying all the allowed vehicles that use the LUPBs. One idea of future developments would be to perform a wider search for entities that use the LUPBs, in order to supply more parking cards. And each entity had to provide the actual time needed to perform their loading/unloading activities. During the observations periods it was possible to identify that there are some deliveries that have to take more than 30 minutes to be accomplished (a big truck unloading supplies to a supermarket), and that there are other types of vehicles that use the LUPBs: vehicles that are related to construction works, and even vehicles that belong to street vendors. The author would recommend creating another parking card for deliveries that would take longer than 30 minutes, but this could generate some difficulty in the attribution of these cards, because the majority of the transport operators would want to be considered an exception, i.e. to have more than 30 minutes for doing its loading and unloading activities.

The author would recommend a combined solution with both technologies, having the sensors on the ground of the parking place and the adapted parking meters on the nearest sidewalk (serving both types of parking: on LUPBs, and the regular on-street parking), following what was done in Bilbao, on the FREILOT project: sensors are used to detect the presence of the vehicle, the schedule of deliveries is defined on a website and an electronic card identifies the vehicle and tells the driver if he is allowed to park. A prediction of the results of a Simplified CBA applied to a solution of this kind is given below (the costs associated with the website were not taken into account):

Table 7.5 - Estimate of the results of a Simplified CBA of the combined solution

	VDS + APM
Time-horizon	15 years
Rate of parking fines in the first year	100%
Parking fines in the first year	47
Total investment in the first year	1.931 €
Net Present Value	6.397 €
NPV prediction for all LUPBs in Lisbon	10.088.725 €

However, the decision between these two ITS solutions would rely on the decision-maker, and if he/she would think that the NPV would be more important, then the To-be APM would be the chosen one. But if the necessity of an automatic and permanent monitoring system was more relevant, then it would be the To-be VDS alternative that would be implemented.

This work encountered several limitations, which were presented above, which opens the way to new studies and future developments.

Other ITS solutions, using other technologies (or other versions of the technologies used), should be tested in Guerra Junqueiro Avenue to provide different results. Projects like the one in Bilbao or in Treviso could be used as guidelines to these new studies, since they use similar technologies (floor sensors and adapted parking meters) and provided good results in those cities. The example from Treviso implemented the floor sensors below the ground, which is a way to avoid the damaging of the sensors trough vandalism acts. The idea of a monitoring system that uses both adapted parking meters and sensors at the same time could be taken from Bilbao (project FREILOT) and also from the experience in Treviso (i-Park Trevisosta), which used a system that includes sensors, adapted parking meters and also variable messaging signs that gave interesting results.

The study of the pilot could be completed with the data needed to proceed with a complete CBA (and not the simplified version that was used in this work) by proceeding with studies focused on analysing the air quality, parking spaces rotation rates, numbers of the abusive occupancy, operating costs of EMEL, polluting emissions, safety of pedestrians, area of sidewalk available for pedestrians, time-savings for the transport operators, and time lost by normal traffic, just to name a few. This new data could be used to perform a more complete CBA, which could give another perspective of the implementation of the sensors and adapted parking meters that were used in Guerra Junqueiro Avenue.

Finally, the pilot should be extended to other parts of the city of Lisbon with the purpose of testing the technologies in different streets with other characteristics (larger, wider, etc.) and other dynamics.

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ANNEXES

ANNEX 1 – PROJECTS AND MEASURES REVIEWED BY THE AUTHOR

Table A1 - List of all projects and measures reviewed

Number	Project	Country of application	Year of application
1	A center for eco-friendly city freight distribution	Italy	-
2	A Delivery and Servicing Plan for the London Borough of Croydon	United Kingdom	2008-2009
3	A Future Role for Urban Consolidation Centers? German Experiences and Prospects	United Kingdom	2005
4	Access control by Euros standards, Region Emilia-Romagna	Italy	2009
5	Achieving “Last Tactical Mile” Supply Chain Visibility Using Active RFID	United Kingdom	2007
6	Antall leveranser og lossetider – Studie av varetransport i byområder	Norway	2008
7	ARIAMIA: electric delivery vehicles for rent in Region Emilia-Romagna	Italy	2002-2003
8	Assessing characteristics of innovative concepts in last mile logistics and urban distribution	Netherlands	-
9	Best urban freight solutions (BESTUFS) – Consolidated best practice handbook	Several European countries	2004
10	Best Urban Freight Solutions II: Control and Enforcement in Urban Freight Transport and City Access Restriction Schemes (pg. 45-46; pg. 54-56)		2006
11	Best Urban Freight Solutions II: Intelligent Transport Systems (ITS) applied to Transport Freight		2007
12	BESTUFS – Good Practice Guide on European Freight Transport (p. 17)	France	2005
13	BESTUFS – Good Practice Guide on European Freight Transport (p. 44-58)	France	2008
14	BESTUFS II – Deliverable D 2.4 Part I – Best Practice Update (2008) – Updated Handbook from Year 2001 – E-Commerce and urban freight distribution (home shopping)	Various countries	2008
15	Byen og varetranporten – tilrettelegging for varelevering i by	Norway	-
16	Cargotram, Zurick	Switzerland	2006
17	Cities-to-cities exchange: Urban Distribution of Goods	European Union	2007
18	City cargo, Amsterdam	Netherlands	2006-2009
19	CITYLOG	France, Germany, Italy	On-going
20	Cityporto, Padua	Italy	2004-2009
21	Cityssimo, La Défense	France	2006-2009
22	CIVITAS ARCHIMEDES	Spain	2008-2012
23	CIVITAS MIRACLES	Spain	2002-2006
24	Clean transport in municipal procurement contracts, Göteborg	Sweden	-
25	Congestion charging, Stockholm	Sweden	2007
26	Consignity, Paris	France	2006
27	Consolidation centers in region Emilia-Romagna	Italy	-

Number	Project	Country of application	Year of application
28	Consolidation of deliveries to four Swedish municipalities	Sweden	1999-210
29	Consolidation of deliveries to London Heathrow airport	United Kingdom	2000
30	CURACAO – Coordination of urban road-user charging organizational issues	Italy, UK, Norway, Netherlands	2006-2007
31	CYCLE logistics: Moving goods by cycle	Various countries	2011-2014
32	Dagrand-distributie supermarkten	United Kingdom	2007
33	Dal- en Nachtdistributie – Bevindingen pilots	Belgium	2010
34	Dal- en Nachtdistributie – Rapport Onderzoeksfase	Belgium	2010
35	Data collection-modeling, Bordeaux	France	2008-2010
36	DHL and Blue Dart pilot “intelligent” delivery trucks in India	India	2011
37	DHL and Blue Dart steer India’s logistics in a new direction with the launch of Smart Truck	India	2011
38	DHL Smart Truck	Norway	2008
39	DIFFERENT	UK, Italy, Germany, Slovenia, Switzerland, Poland, Netherlands, Spain, France, Norway	2006-2008
40	Dynamic delivery areas, Poitiers	France	2007
41	Ecologistics, Parma	Italy	2004-2006
42	ECOSTARS Fleet Recognition Scheme	Various countries	2011-2014
43	EDRUL	Portugal, Italy, Netherlands, Denmark	2002-2005
44	Elcidis urban consolidation center, La Rochelle	France	2001
45	ELP: Espace Logistique de Proximité, Bordeaux	France	2003
46	EPC in Action – The GS1 EPCglobal Transport and Logistics RFID Pilot		-
47	EPCIS and Its Applications	Japan	-
48	European Interdisciplinary Research on Intelligent Cargo for Efficient, safe and Environment - friendly Logistics - (EURIDICE) – Exploitation opportunities	Finland, Sweden, Norway	2011
49	FIRE project – Final Report for Publication	Several EU countries	2000
50	FORS: Freight Operators Recognition Scheme, London	United Kingdom	2009
51	Freight Consolidation Center Study	United Kingdom	2010
52	Freight distribution plan, Bologna	Italy	2002-2006
53	Freight Information Portal, London	United Kingdom	2009
54	FREILOT – Urban Freight Energy Efficiency Pilot	Netherlands, Spain, France, Poland	2009-2012
55	Future Solutions for goods distribution	United Kingdom	2006-2009
56	Godstransporter i by	Norway	2007
57	Heathrow Airport Retail Consolidation Center	United Kingdom	2002
58	HVF: Heavy goods Vehicle Fee on local and urban roads in Swiss cities	Switzerland	2001
59	Implementation of a Delivery and Servicing Plan for the London Borough of Sutton	United Kingdom	2008-2009
60	IMPRINT-EUROPE		2001-2004

Number	Project	Country of application	Year of application
61	INTEGRATIVE FREIGHT DEMAND MANAGEMENT IN THE NEW YORK CITY METROPOLITAN AREA	US	2006
62	Integrative Freight Demand Management in the New York City Metropolitan Area	US	2009-2010
63	Inter-city coordination, Region Emilia-Romagna	Italy	2002-2009
64	INTERSYS final report – RFID support for identification and control of shipments, control units and wagons in intermodal transport systems	Sweden	2010
65	Investigating RFID for roadside identification involving freight commercial vehicle operators (CVO)	US	2010
66	Life CEMS, Lucca	Italy	2005-2010
67	LLCS: London Lorry Control Scheme, London	United Kingdom	1985
68	London construction Consolidation Center	United Kingdom	2006
69	Lorry routes in Region Emilia-Romagna	Italy	2000-2006
70	Lorry routes, Bremen	Germany	2005
71	Low emission zone, London	United Kingdom	2008
72	Low emission zone, Utrecht	The Netherlands	2007
73	MIRACLES: Multi Initiative for Rationalised Accessibility and Clean Liveable Environments. Annex I : Rome	Italy	2006
74	MIRACLES: Multi Initiative for Rationalised Accessibility and Clean Liveable Environments. Annex II : Winchester	United Kingdom	2006
75	MIRACLES: Multi Initiative for Rationalised Accessibility and Clean Liveable Environments. Annex III : Barcelona	Spain	2006
76	MIRACLES: Multi Initiative for Rationalised Accessibility and Clean Liveable Environments. Annex IV : Cork	Ireland	2006
77	MIRACLES: Multi Initiative for Rationalised Accessibility and Clean Liveable Environments. Final Report	Spain, UK, Italy and Ireland	2005-2006
78	Mobility Master Plan including freight, Paris	France	2007
79	MOSCA – Decision Support System For Integrated Door-To-Door Delivery: Planning and Control in Logistic Chains	Germay, Italy, Switzerland	2000-2003
80	Motorola's travel and transportation RFID solutions	US	2007
81	Multi use lanes, Barcelona	Spain	2000
82	Night deliveries experiment, Barcelona	Spain	2006-2008
83	Night-time deliveries – Wandsworth trial	United Kingdom	2007
84	Packstation for B2B in German cities	Germany	2002
85	PARFUM – Demonstration Bremen	Germany	2006-2009
86	Partnership on good practices, Toulose	France	2004
87	Petite Reine (electrically tricycles for deliveries)	France	2003-2006
88	Pick up points for B2C, French cities	France	1989
89	Protected delivery zones, Prague	Czech Republic	1999
90	Reducing the impacts of freight operations in urban centers through out-of-hours deliveries	United Kingdom	2007
91	RegLog City Logistics in Regensburg	Germany	1998
92	SAMLIC Pilotförsöket	Sweden	2004
93	Silent deliveries with piek labelling, Dutch cities	The Netherlands	2007-2009

Number	Project	Country of application	Year of application
94	SMARTFREIGHT: Implementation specification for new extended management and freight distribution management functionality		2008-2011
95	Spedithun, Thun	Switzerland	2000
96	Standard International Logistic Label - STILL	Belgium	2008
97	START – Short Term Actions to Reorganize Transport of goods	Italy	2006-2009
98	Steps towards a Future FMCG Supply Chain	Latvia	2009
99	SUGAR – Good Practices Analysis – Deliverable 3.3 (p. 198-205)	France	2008-2012
100	SUGAR – Good Practices Analysis – Deliverable 3.3 (p. 261-266)	France	2008-2012
101	SUGAR – Good Practices Analysis – Deliverable 3.3 (p. 33-38)	France	2008-2012
102	SUGAR: Sustainable Urban Goods Logistics Achieved by Regional and Local Policies		2008-2012
103	Take Cargo	Norway	-
104	Technical guidelines for delivery spaces, Paris	France	1994 - 2005
105	TRAILBLAZER: Report on the State of the Art	UK, Sweden, Italy, Germany	2010-2013
106	TURBLOG: Transferability of urban logistics concepts and practices from a worldwide perspective	Portugal, the Netherlands, United Kingdom, Brazil, Peru, India, China, Japan, United States	2009-2011
107	UCC: Motomachi Urban Consolidation Center, Yokohama	Japan	2004
108	Urban Consolidation Center, Bristol	United Kingdom	2004
109	Urban Freight – Transport and Logistics	Belgium	2006
110	Urban Freight Case Studies: Los Angeles	United States of America	2009
111	Urban Freight Case Studies: New York	United States of America	2009
112	Urban Freight Case Studies: Orlando	United States of America	2009
113	Urban Freight Case Studies: Washington DC	United States of America	2009
114	Urban Freight Consolidation Centers	United Kingdom	2005
115	Urban Logistics Spaces, Paris	France	2001-2009
116	Urban Logistics Terminals, Tokyo	Japan	-
117	Urban rail logistics: Monoprix, Paros	France	2007-2012
118	Using building code regulation for off-street delivery areas, Barcelona	Spain	1999
119	Zum Handeln Geschaffen - How METRO GROUP benefits from global standards	Germany	2011
120	Electronic Freight Management Case Studies	United States of America	2012

ANNEX 2 – ESTIMATE OF THE HUMAN RESOURCES COSTS

The author had to do the following assumptions:

1. The time necessary to monitor both sides of the avenue is 60 minutes.
2. Each parking fine takes 5 minutes to be issued.
3. The parking officers monitor the avenue 3 times per day.
4. The parking officers take an average 5 minutes to reach the avenue when alerted by the OCC (in the To-be VDS alternative).
5. The average number of parking fines detected each year per parking place is 260 fines on the west side, and 416 on the east side.

COSTS PER MINUTE

To estimate the human resources costs the author first calculated the costs per minute, based on the following:

- The costs per month with Parking Officers assigned to monitor the avenue during the pilot where 800€.
- Each month has 20 business days, with 8 working hours each.

We now have the value:

$$Costs\ with\ Parking\ Officers\ per\ min = \frac{800€/month^{7}}{20 \times 8 \times 60} = 0{,}08(3)/min$$

TIME NEEDED TO MONITOR THE LOADING/UNLOADING PARKING SPACES

The next step is to estimate how much time these Parking Officers need, to monitor the loading and unloading parking spaces. The author counted the number of regular parking spaces on both sides of the avenue: 93 on west side (APM side), and 94 on the east side (VDS side); and also the loading and unloading parking spaces: 8 on west, and 9 on east.

[7] This value was given to the author by Óscar Rodrigues and it already includes the deduction of all taxes. It represents the monthly cost of a Parking Officer to EMEL.

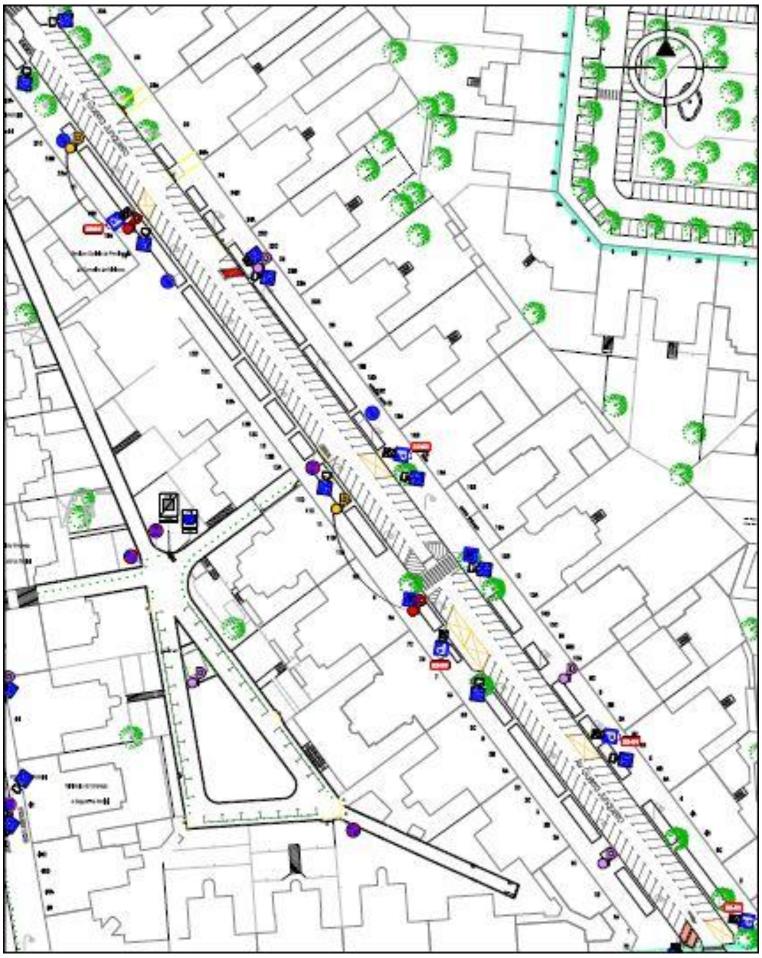

Figure A2 - Schematic of Guerra Junqueiro Avenue

With this data it is possible to calculate the time needed to monitor a single parking space (note that the loading/unloading parking spaces of the VDS solution don't require to be monitored by the Parking Officers):

$$Time\ needed\ to\ monitor\ a\ single\ parking\ space = \frac{60\ minutes}{93 + 94 + 8} = 0{,}31 min$$

Now we can estimate the total time needed to monitor the loading/unloading parking spaces of the west side of the avenue (APM side) on each day:

$$Time\ allocated\ to\ monitor\ the\ APM\ side = (0{,}31 min \times 8 \times 3) = 7{,}4\ \mathrm{min}$$

We have to consider that the avenue is monitored on weekdays (5 days) and half of Saturdays (counted as 0,5 day), and we have to add the time needed to issue the parking fines (5 minutes). We can compute now the total time allocated to the APM system per year (52 weeks):

$$Time\ for\ monitoring\ the\ avenue\ per\ year = 7{,}4\ \mathrm{min} \times (5 + 0{,}5) \times 52\ weeks = 2112\ min$$

$$Time\ for\ issuing\ parking\ fines = 260 \times 5 min = 1300\ min$$

$$Total\ time\ allocated\ to\ the\ APM\ per\ year = 2112 + 1300 = 3412\ min$$

As for the To-be VDS alternative we only have to take into account the time the parking officers take to reach the avenue after they receive an alert by the OCC (average of 5 minutes) and the time they take to issue the parking tickets (5 minutes each):

$$Time\ allocated\ to\ the\ VDS\ on\ each\ year = 416 \times (5min + 5min) = 4160\ \mathrm{min}$$

COSTS WITH PARKING OFFICERS (HUMAN RESOURCES)

$$APM: Costs\ with\ Parking\ Officers\ per\ year = 0{,}08(3) \times 3412 = 284{,}33\ €/year$$

$$VDS: Costs\ with\ Parking\ Officers\ per\ year = 0{,}08(3) \times 4160 = 346{,}67\ €/year$$

We can estimate the costs with human resources for other number of parking fines because these two variables are directly proportional, but it's important to notice that the costs of the APM have fixed costs regarding the monitoring of the avenue.