

## Designing an environmental zone in a Mediterranean city to support city logistics

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**Abstract:** European cities are facing enormous challenges in accessibility and livability terms due to several European directives, which are compulsory in the mid/long term, traffic congestion levels are still increasing, and air pollution and noise disturbs citizens' lives. This work presents the study carried out in a Mediterranean city to define an Environmental Zone with traffic restrictions for vehicles in the historical centre of the city of Cartagena (Spain) by exploring different urban logistics measures to tackle main problems caused by freight deliveries and pickups in the city centre. These solutions aimed to enhance the efficiency of vehicles, and to reduce both traffic congestion the environmental impacts caused by freight delivery in the city in order to improve urban sustainability.

**Key words:** Environmental Zone, Urban freight transport, Sustainable urban mobility, City logistics.

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### 1. Introduction

The main priority of authorities is to constantly search for feasible economical solutions in urban logistics problems, such as traffic congestion and parking difficulties, inadequate public transport, environmental impacts and energy use, accidents and safety, freight distribution, automobile dependency, etc. (Bulkeley & Betsill, 2005).

Several European directives, which are compulsory in the mid/long term, have led many European cities to propose solutions in accessibility and livability terms because congestion levels are still increasing, and air pollution and noise disturb citizens' lives. (Newman & Kenworthy, 1999; Southworth, 2003;

EU-COM, 2011). A clear trend towards increasing pedestrian areas in city centres is the common solution for local authorities (Appleyard, 1981; Engwicht, 1999; Crawford, 2000).

Although city centre pedestrianisation has led to certain problems appearing, such as limited parking areas, traffic access limitations, difficulties to deliver operations, as well as difficult access for the neighbours who live in these areas, urban transport issues have become more important to better support life for people, and towards a better environment in urban areas (Dabanc, 2008). Therefore, balancing smart economic activities and cleaner, quieter, and safer communities are needed to create more sustainable and liveable cities (Taniguchi, 2014).

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Different European projects, like CIVITAS, together with the EU Commission Transport 2050 Strategy, set goals for different transport modes, including CO<sub>2</sub>-free city logistics in major urban centres by 2030 (EU-COM, 2011; Van Roijen & Quak, 2014; Dotter, 2015).

Our research group is exploring different urban logistics measures to tackle the main problems caused by freight deliveries and pickups in the city centre. These solutions aim to enhance the efficiency of vehicles, and to reduce both traffic congestion and the environmental impacts due to freight delivery in the city in order to improve urban sustainability.

This work is arranged as follows: Sections 1 and 2 present a brief literature review about environmental zones (EZ), European projects on urban logistics and different outlines developed in European cities; Section 3 defines the proposal of an EZ, its characteristics and the objectives to pursue with it, as well as the work methodology followed to study and implement it. Section 4 presents the main actions that the local authority must take for the EZ, the expected results after the first year of the EZ in operation, and the initial measures taken by the City Council. Finally, this paper ends with the conclusions drawn from the research done on the developed EZ.

## 2. Environmental Zones in EU

An Environmental Zone (EZ) is a defined geographical area that can be entered only by vehicles that meet specified emissions criteria (Allen & Wild, 2008). The purpose of an EZ is to either restrict or charge the most polluting vehicles if they enter the EZ when their emissions are over the set level. EZs are implemented into locations in which air pollution can (has reached) reach levels that are dangerous to public health. By introducing an EZ it is hoped that air quality improves and this will reduce the health problems and fatalities associated with poor air quality. Given this health hazard, the European Union, and many countries around the world, have set air quality targets to be met, and Low Emission Zones are being implemented (Allen & Wild, 2008; Browne *et al.*, 2012; Dotter, 2015).

This can be applied to different types of vehicles (only goods vehicles, a selection of motor vehicles, all motor vehicles). An EZ, therefore, differs from the following types of access restrictions that can be placed on goods vehicles in urban areas: weight,

length, time restrictions, loading capacity, etc.). However, the types of access restrictions can be implemented in addition to an EZ. Environmental Zone Schemes can take many forms according to their objectives, the geographical area they cover, the times at which the EZ comes into force, the vehicle emissions standards required for vehicles to enter zones, the types of vehicles that need to comply with the EZ, and the implementation and enforcement approaches used (Allen & Wild, 2008; Russo & Comi, 2012).

Environmental Zones have been successfully implemented and run for several years in Scandinavian countries, and are widely considered by other European cities (London, Bologna, Madrid), and countries (Austria, Italy, Germany, The Netherlands, Denmark). Several schemes have already been implemented, according to the problems and specific characteristics of the city or region.

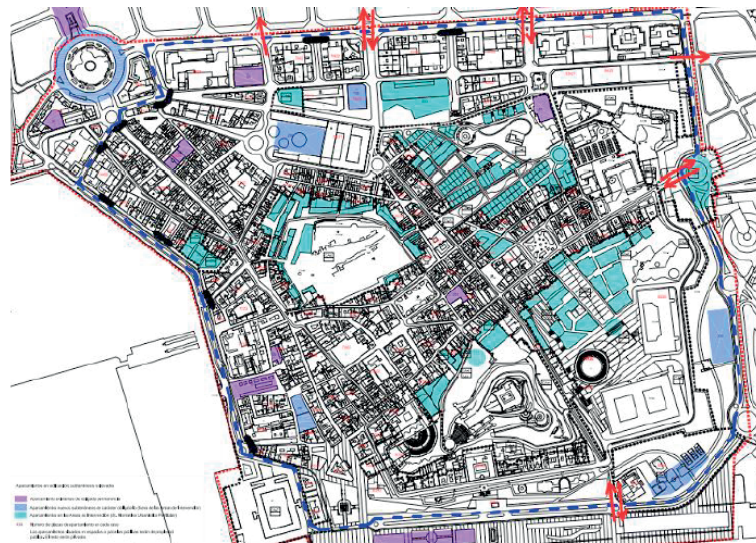
The implementation of an Environmental Zone usually requires cooperation between the national government and local authorities to help ensure a common system within a city, and further in a region and in the country (Geroliminis & Daganzo, 2005; Witkowsky & Kiba-Janiak, 2014). Given current EU policies and the link among the use of infrastructure, air quality and noise problems, EZs are relevant from a EU perspective in the road traffic restrictions context (Geerling & Stead, 2003).

## 3. Proposal of an Environmental Zone in Cartagena

### 3.1. Methodology

The paper presents a study carried out to define an Environmental Zone, with traffic restrictions for vehicles, in the historical centre of the Spanish Mediterranean city of Cartagena, and the stages for its implementation, which will be properly performed by local authorities.

The present research was conducted according to not only the recommendations of the work group in BEST Urban Freight Solutions II (Allen & Brown, 2008; Allen & Wild, 2008), but also to the Taniguchi methodology (Taniguchi *et al.*, 1999), which is based on three fundamental aspects of an urban functional area: collecting data that allow to characterise and quantify transport in the study area; determining and describing any existing problems inside it; solving



**Figure 1.** Definition of the boundary of the Environmental Zone, entry and exit streets.

the considered problems by defining alternatives for modelling the studied urban functional area.

The main objectives of establishing this EZ are to limit road traffic, and to promote walking and cycling, with the following benefits: reducing pollutants (atmospheric, noise, etc.), and supporting the tourist activities in the Mediterranean city, and without detriment to commercial activities and supplying businesses located inside the EZ.

The steps of the work methodology followed to define this EZ and its operation are:

- Step 1: Defining the geographic boundaries of the EZ, fixing the entries and exits of the EZ, and closed streets during its operation (Figure 1).
- Step 2: Access control system and communication plan to citizenship.
- Step 3: Evaluating the parking areas inside the EZ and a proposing deterrent parking areas outside the EZ.
- Step 4: Establishing entry requirements for the EZ (types of vehicles, schedules, special permissions, etc.).
- Step 5: Progressively implementing the EZ. Analysing the results of the various defined and taken actions.

### 3.2. Definition of an Environmental Zone

The proposed area to implement an EZ covers the entire historical centre of Cartagena, but does not include most of the later city expansion. This area covers approximately 1.55 km<sup>2</sup>, and is delimited by the large avenues and the city's promenades.

This is the most representative area of the city, where an urban plot is conditioned by the topography, narrow streets are irregular in width and of medium or short length, and most have been recently pedestrianised (PEOPCH, 2005). The old town houses numerous historical buildings, whose use is usually administrative, educational, cultural, military or services, and they generate high flows of people in the city. The described set of elements is the basis of an urban fabric characteristic of a Mediterranean city model, whose social life is cohesive with a system of neighbourhood diversity, public spaces, and historical and cultural buildings.

Figure 1 shows the different aspects that define the Environmental Zone (EZ):

- the border of the EZ: denoted by a blue dotted line.
- the entry and exit points of the EZ (denoted by a double red arrow). The research group located four different entries and exits along the delimited perimeter. The current traffic directions

on the streets inside the EZ were not changed for the area to better operate.

- the streets (marked by black strokes) are closed by heavy elements and mobile devices (e.g. flowerpot stands, planters, etc.) and are easily removable for future changes and activities in the delimited area (Figures 2.1 and 2.2).



Figure 2.1. Streets closed by removable elements.



Figure 2.2. Streets closed by removable elements.

### 3.3. Objectives of the Environmental Zone

The creation of the EZ in the city centre intends to reduce pollutants in the defined area (emissions of air pollutants, noise pollution, etc.), to encourage walking and cycling in the urban core, and to support the city's touristic activity (Southworth, 2005; EU-COM, 2011; Browne *et al.*, 2012; Childers *et al.*, 2014). These actions will improve air quality and cut road traffic, which will thus reduce respiratory diseases and the number of traffic accidents, which will have indirect effects on the city's economy (Southworth, 2003; Lindholm, 2012; Quak, 2015)).

Reducing commuting, encouraging cycling or simply walking increase the commercial activity in former heavy traffic zones (Russo & Comi, 2012; Pulawska & Starowicz, 2014).

Nor should we forget the city's important tourism aspect, which will benefit from the EZ as tourists, many of whom come on cruiser trips, will enjoy a more complete experience of the city thanks to streets being decongested of motor vehicles.

Finally, it is stressed that the creation of the EZ in the city centre of Cartagena continues with the roadmap to further improve both the quality of life for neighbours and the sensations lived by tourists in the city. This process began two decades ago, and Cartagena has gone from being one of the most polluted Spanish cities to being a pole of tourist attraction, thanks to the different actions performed by the local authority to achieve its reconversion, and to combine powerful industry (outside the city) and booming tourism.

### 3.4. Concentration areas inside the EZ

The work team analysed the population distribution and the current points where vehicles concentrate inside the EZ.

The population inside the EZ is homogeneously distributed in several sectors that compose the EZ, except in two very specific sectors, which are being used as non-official parking areas.

Given the high concentration of vehicles in these two sectors, the entry into force of the EZ will affect many current users, so the Cartagena City Council must propose alternatives in these cases that are to be considered (deterrent parking, shuttle buses, etc.). These nuclei where vehicles concentrate will be considered at the time the EZ of Cartagena is planned:

- Sector 1: UPCT (Campus "Muralla del Mar"): this sector houses two University faculties (ETSII & ETSIT), which together contain around 4,000 students, many of whom need to use own vehicles. The car park is located in front of the two faculties and runs peripherally to their façades (see Figure 3).
- Sector 2: Montesacro. This is a car park on the land around the Mount Sacro, where a large number of vehicles are park daily by the workers in the area and by the neighbours who live in this sector (see Figure 4).



Figure 3. Car park around UPCT buildings.



Figure 4. Car park around Mount Sacro.

## 4. Actions to implement the Environmental Zone

The EZ in Cartagena will be an open space supervised by cameras, with no access restriction elements, but with clearly identified entry and exit points. It will be a similar model to that which is currently operating in the city of London (Geroliminis & Daganzo, 2005; Allen & Wild, 2008; Van Rooijen & Quak, 2014; Witkowski & Kiba-Janiak, 2014), but it will be adapted to the characteristics of a medium-sized Mediterranean city.

To implement the EZ, an integrated database will be created, formed by all the vehicle number plates whose users have indicated (via web) their intention to access the EZ as they work, study or live inside the EZ.

To raise the awareness of the affected groups, the local council will open a 6-month adaptation period, during which the performance of the EZ will be publicised by mass media (radio, TV, the council's website, etc.).

In addition, notices of non-compliance will be issued by the authorities, and will attach the sanction that applies to them if visitors to the EZ commit the infraction again once the awareness campaign has ended.

### 4.1. General requirements to access the EZ

Entry requirements for the different groups that claim access to the EZ will be based on emission levels of airborne and/or malicious life pollutants (NOx, CO, HC, PM, HNCM), type of engine (petrol or diesel), heavy or light commercial vehicles, trucks and buses, and types Euro 0, I, II, III, IV, V, and VI.

For electric vehicles, the total exemption of costs is proposed, while a 50% bonus of the amount envisaged to access the EZ is proposed for hybrid vehicles.

#### 4.1.1. Entry requirements for residents and workers in the EZ

In spite of the benefits and improvements of the quality of life inside the EZ, the implementation of an EZ can be disrupt the daily life of the populations inside it:

1. Entry requirements based on the hazardous potential of vehicles will not be applied immediately to residents, but will develop following this schedule: EURO I - January 2018, EURO 2 - January 2020, EURO 3 – January 2022.

In this way, the local authority ensures an acceptable deadline to replace the vehicles that do not comply with emission regulations.

2. For the workers whose job is located inside the EZ, they will be guaranteed access provided they meet the general entry conditions and employers pay the access fee. Access procedures will be carried out by employers on the website enabled for this purpose.

3. For students, whose educational or research centre is located inside the EZ, they will have unlimited entries during the academic course. Access procedures will be processed during the academic enrolment period.

#### *4.1.2. Entry requirements for delivery vehicles to the EZ*

Every company that undertakes its economic activity (e.g. product deliveries) inside the EZ must comply with the general requirements to be able enter the EZ. In the same way, the company will follow the administrative process to register in the database all the vehicles that will enter the EZ.

Time slots shall be established for loading/unloading operations, for a maximum time of 30 minutes to carry out the operation and to leave the EZ, during two time windows in the daytime: from 09.00h to 11:00h (in the morning) and from 16:00h to 18:00h (in the afternoon).

In this way, each vehicle can access the EZ only once a day, but can enter and exit up to a maximum of 3 times if its time inside the EZ takes less than 45 min (optimal solution for fast messaging companies).

#### *4.1.3. Special access licenses to the EZ*

This section presents exceptional situations that require access to the EZ (not covered in the previous sections), and they will be attended to by a system of temporary access permits (from 3 days to a maximum of 15 days):

- Licenses for temporary access granted to a vehicle that visits a resident,
- access licences for hospital stayings or other medical services,
- access licences for tourists, hotels and vacation apartments in the EZ,
- other special licences.

## **4.2. Control of access to the EZ and sanctions**

An open character access to the EZ has been chosen, and no physical elements will be installed

that regulate entries (lifting barriers or pivots). The access control will be completely automated through a system of cameras located at the EZ entry and exit points, a completely trustworthy and reliable system that ensures compliance (as in the London EZ).

The artificial vision system will recognise number plates and will determine if the access of this vehicle is allowed inside the EZ.

Entry permits granted to residents, workers and students will be valid for one year, after which the these permits will no longer be valid and must be renewed following the same process (via the website, Council Office, etc.) as when it was first obtained.

Those vehicles that have accessed the EZ without authorisation will be automatically sanctioned by attaching to the sanction a photograph taken while the infraction was committed.

Economic sanctions are foreseen for those vehicles that access or circulate inside the EZ without a valid access license. This sanction will be imposed only on the same vehicle once a day.

Generally, all penalties may be claimed during the first 15 days after receiving them should any error have been made while issuing the penalty.

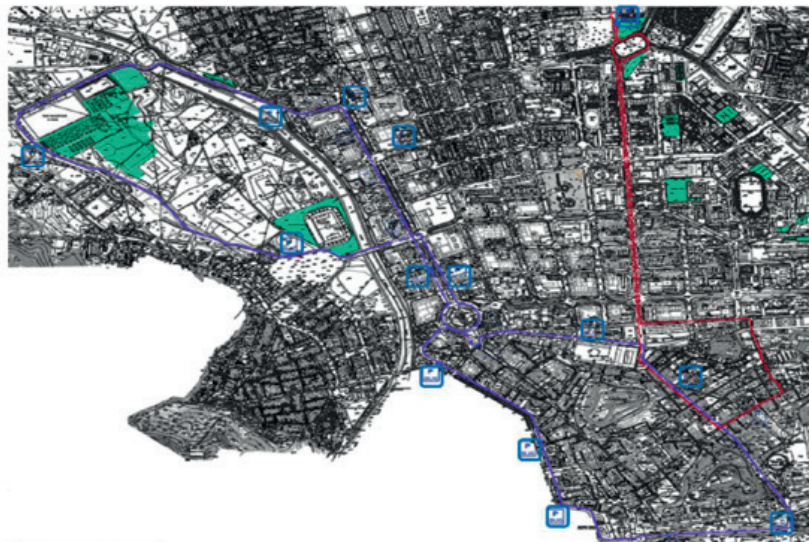
## **4.3. First actions developed to start the EZ**

At the end of 2016, the Department of Sustainable Development (Cartagena City Council) began to take different actions to progressively eliminate vehicles in the historic centre.

One of the first proposed solutions was to create park-and-ride areas outside the EZ, whose construction can lead to better EZ performance since they combine the flexibility of a car and the efficiency of public transport. It will be necessary to devise a plan that defines the type of more adequate parking areas according to the EZ, its performance and its functional environment.

Last Christmas the local authorities launched two new free bus lines that connected two existing park-and-ride areas with the city centre (Figures 5 and 6).

The results were not those expected (only 7% of people visiting the historical centre came by bus)



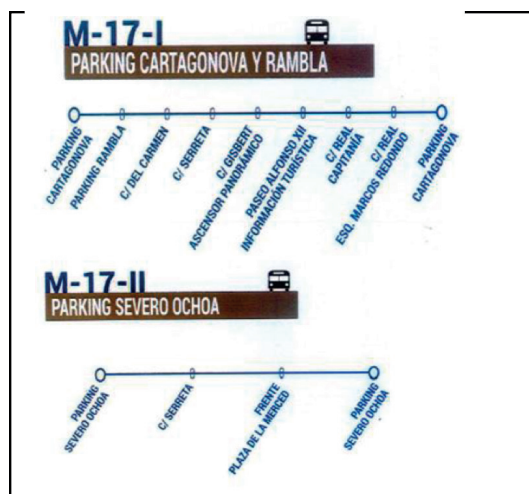
**Figure 5.** Location of possible park-and-ride areas outside the Environmental Zone.

due to lack of publicity about the new bus lines, their routes and stops, and the temporary duration of this campaign.

The campaign has been repeated during two other festive periods, (Easter and the “Carthaginians and Romans” festival last September). On both occasions, the use of free buses has progressively increased (from 7% to 15% and 20%, respectively), and the City Council is considering making this service permanent with the mid-term implementation of the EZ because making these bus lines permanent would encourage their use (PEMC, 2017).

Finally, in order to ensure citizen security in Cartagena given the large influx of tourists in summer and

autumn, and as a result of the latest terrorist actions in some European cities, the local police have taken several actions that the research team considers are an example of bad practices (see Figures 7.1 & 7.2). The local police have made it difficult to enter the main street using police vehicles. Rather than a dissuasive measure, it can cause difficulties for disabled people to access and problems if large groups of people are present.



**Figure 6.** New bus lines between the EZ and the park-and-ride areas.



**Figure 7.1.** Street closed by a police car on the Main Street of Cartagena.



**Figure 7.2.** Street closed by a police car on the Main Street of Cartagena.

#### 4.4. Benefits of implementing an EZ in Cartagena

As previously mentioned in Section 3.2, Cartagena is a medium-sized city. The area selected as the EZ is characterised by having narrow streets of irregular widths and most have been recently pedestrianised. This means that as the city’s tourist centre, the daily urban logistics for the different establishments inside the EZ to operate is becoming increasingly complex.

A study recently conducted by the research group (De la Fuente *et al.*, 2015) establishes almost 6,500 motorised vehicle entries into an EZ on one working day morning. Of these, 15% were freight distribution vehicles, and 85% were public and private vehicles used to transport people. Bicycle use was minimum (0.01%) compared to motorised vehicles.

The heavy vehicle flow, along with the proximity to a large industrial and port area, implies that air quality levels (PM10, NOx, CO, etc.) are not in line with those expected for a medium-sized coastal city. The values recorded last month (November 2017) fell within the range [65-75%] of values allowed by the EU, but the local authorities hope to reduce them to go below 50%, which is the reason why they have collaborated to develop the EZ in Cartagena.

In general, depending on the stringency of the EZ standards the potential socio-economic effects of the EZ in a city (based on the feasibility study of the London EZ) are to become possible future benefits (Geroliminis & Daganzo, 2005; Browne *et al.*, 2012; van Roijen & Quak, 2014; Dotter, 2015):

<b>BENEFITS</b>
Improved air quality –all pollutants (not just NO <sub>2</sub> and PM10)
Progress towards EU air quality limit values
Health benefits – lost time at work, NHS costs
Slight reduction in noise
More attractive environment for companies and people
Safety benefits of newer vehicles
<b>DISSADVANTAGES</b>
Higher potential business costs for companies (which could negatively affect attractiveness)
Stronger relative impact on road haulage, wholesale, trade, manufacturing sectors, building companies
Stronger relative impact on smaller companies

Given the results expected for the city of Cartagena, and after implementing the EZ and it operating for 1 year, it has been estimated that:

- More than 20-30% of motorised traffic inside the EZ will reduce.
- The use of private vehicles (15-25%) will be replaced with non-motorised vehicles (bicycles, e-bikes, etc).
- NOx emissions from heavy vehicles inside the zone will lower by 10%
- Emissions of particulates will lower by 30%
- Sales of the establishments inside the EZ will increase by 10-20%.
- More shops will open (approx. 7.5%)
- There will be more health benefits and fewer hospital admissions, by 20% of present rates.

## 5. Conclusions

European cities are facing enormous challenges in accessibility and livability terms. Congestion levels are still increasing. Air pollution and noise disturb many people who live in city centres. Most European cities are seen as living laboratories for conducting innovative urban sustainability measures.

After studying the behaviour and performance model for the selected functional urban area (historical centre), in this paper the research group presents the EZ defined at the city centre of a Mediterranean city (Cartagena), where it will either restrict or charge the most polluting vehicles that enter this geographical area. The research group is planning a set of possible solutions:

- Entry permits for certain types of delivery vehicles and restrictions for other types.
- Bundling and guided routes for goods deliveries.
- Use of clean vehicle technologies, etc.

The Local Administration will be in charge of executing the feasible proposed solutions, but it will require the collaboration and conviction of the population that lives and works in the EZ.

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