UNIVERSIDAD DE LAS PALMAS DE GRAN CANARIA

Tides
INSTITUTO UNIVERSITARIO DE TURISMO Y DESARROLLO ECONÓMICO SOSTENIBLE

MSc in Tourism Transport and Environmental Economics

THE ROLE OF TRANSPORT IN THE SMART CITIES

Marta I. Santana Beneyto

45345148-G

Supervised by: Juan Carlos Martín Hernández

Las Palmas de Gran Canaria

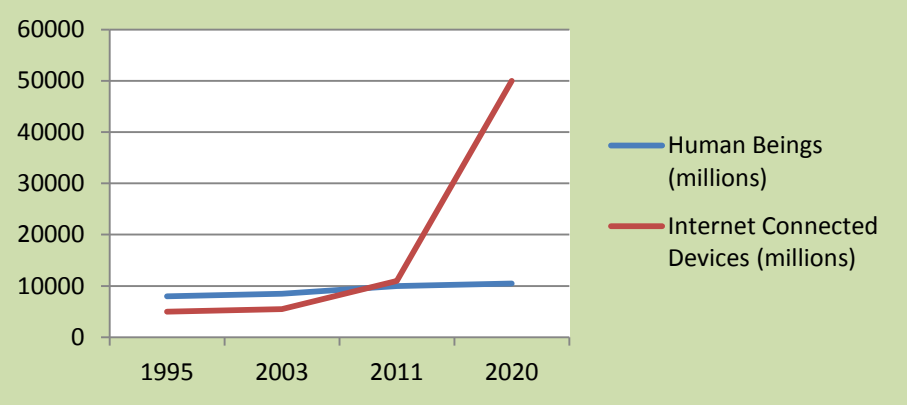
11/06/2015

ABSTRACT

Two main concerns affect developed cities: **urban congestion** and **global warming**. These two concepts walk together because more urban congestion would suppose an increment in transport needs which cause traffic congestion and, for this reason, more pollution.

Hence, the aim of this work consists in develop a theoretical transport model in which, at least, these two concerns will be analyzed. The base of the model is Information and Communication Technologies (IT). Devices connected to the internet have already surpassed the number of people worldwide. Social network and all kind of devices daily generate huge amount of information.

Figure 1: Human Beings VS Internet Connected Devices



Source: INDRA (2015), p. 5.

With technology of "Internet of Things" this information could be applied in order to create better societies, less pollutant and better organized which increase citizens quality of life. Internet is not only a global network for people to communicate. It is a platform which allows devices to communicate between them and with the rest of the world by itself.

"Internet of Things" and the organization of Big Data (label given to all data collected) across a powerful platform would allow this incredible amount of data to be used in order to make things be Smart Things within the context of the Smart City.

However, apart from benefits emerged from the performance of the model, it supposes some risks that also are analyzed in the current work and recommendations are proposed to minimize the possible impact.

Key words: Internet of things, Big Data, Smart City, Transport, ICT

TABLE OF CONTENTS

LIST OF FIGURES

LISTS OF TABLES

1. INTRODUCTION

During last decades, developed societies, among which Spanish is found, have been experienced an increment in urban areas population congestion. The main consequence remaining from this issue is that this concentration would generate system unsustainability.

Unsustainability would be caused mainly because of the performance of transport sector. Transport sector is known as the conjoint of both freight and passenger transport and activities involved in the process within the context of a transport network.

The more people living in cities, the more demand, and, because of this, the more **freight transport** in the city. In addition, **passenger transport** will also rise because people need to move around and out of the city. The conjoint of these two facts would affect more fields than we can imagine. It affects the energetic model, consumption, oil reserves at accessible prices, greenhouse emissions (which impacts directly to cities' air quality and to global warming in general), land and to water use among others[1].

Consequently, global warming trend will rise due to more pollution, not only because of the need of more vehicles for passenger transport but for the traffic congestion in cities.

People and freight mobility is specifically related to communities' development and social interaction. Implications of the way transport is used are huge and without efficient transport systems cities and trade could not exist. This sector has increased its importance due to the globalization, which implies an increase in the amount of goods and passengers exchanges worldwide.

So, here it is the dilemma. Transport is extremely important in our lives but, at the same time, global warming is one of the most important problems worldwide. The question is: Is it necessary to reach the limit that the world could withstand? "We simply do not have the luxury of losing another decade; it will be extremely costly reach the climatic stabilization[2]".

1.1. Aim of the work

In this Master Thesis the goal is, first of all, analyze the Smart City concept, what is it and what does this new city paradigm implies in terms of transport, showing the necessity of a new way of transport, more sustainable and intelligent, and the idea of a new transport network more integrated.

Secondly, we will try to put our focus in Las Palmas de Gran Canaria City, Spain, one of the Spanish cities included in "Red Española de Ciudades Inteligentes"[3], which is trying to improve in terms of city intelligence.

Lastly, we will try to make a reflexion and a "reactive" proposal presenting a generalized model called **Smart Mobility model** based on the analysis of the current transport situation in Las Palmas de Gran Canaria city and in the application of ICT[4] for its performance.

[1] Real Academia de Ingeniería (2009), p.1.
[2] Ottmar Edenhofer; cited in Gilillis, J. (2014).
[3] "Spanish network of Smart Cities".
[4] "Information and Communication Technologies".

However, the model emerged from this work could be applied to any city by doing a previous analysis of the city itself instead of an analysis of Las Palmas de Gran Canaria.

1.2. Methodology

Table 1: Applied Methodology

STEP 1: work planning	- Documentary review. - Aim of the work. - Work structure.
STEP 2: work preparation and elaboration	- Preliminary reunions - Analysis of the current situation - Model proposal
STEP 3: Analysis and results presentation	- Results analysis - Conclusions and limitations

Source: own preparation

1.3. Structure

As a result of the previous study, project development has followed the next structure:

1. Introduction: brief explanation of the work and its importance, definition of the main objectives and applied methodology.

2. Theoretical framework: Smart City definition and problems like city congestion and what is the role of transport in it.

3. Spain and Las Palmas de Gran Canaria: here population situation is treated and then, more deeply, in the case of Las Palmas de Gran Canaria, it "Smart city degree" is addressed.

4. Model: in addition to the Smart Mobility model, concepts like sensors, "Internet of Things" and Big Data are described.

5. Stakeholders and benefits: benefits emerged from the performance of the model classified into each stakeholder's own benefits.

6. Risks associated to the model: risks derived from the model performance analysis and recommendations to minimize them.

7. Conclusions and limitations

2. THEORETICAL FRAMEWORK

2.1. Urban Transport congestion problem

Now we have put on the table that population congestion is a real phenomenon that cities have to deal with. This will have two main effects in urban transport. On the one hand, it will increase freight demand within cities. Companies would have to satisfy needs of a greater population and, for that, they will need more vehicles, generally trucks and vans, which carry all the stuff. On the other hand, passenger transport demand will also rise, not only because there will be more vehicles but because of public transport services will need to be amplified in order to satisfy all population.

Therefore, one of the main causes of transport congestion in urban areas is its rising demand trend (both freight and passenger), due to the greater population concentration in those areas.

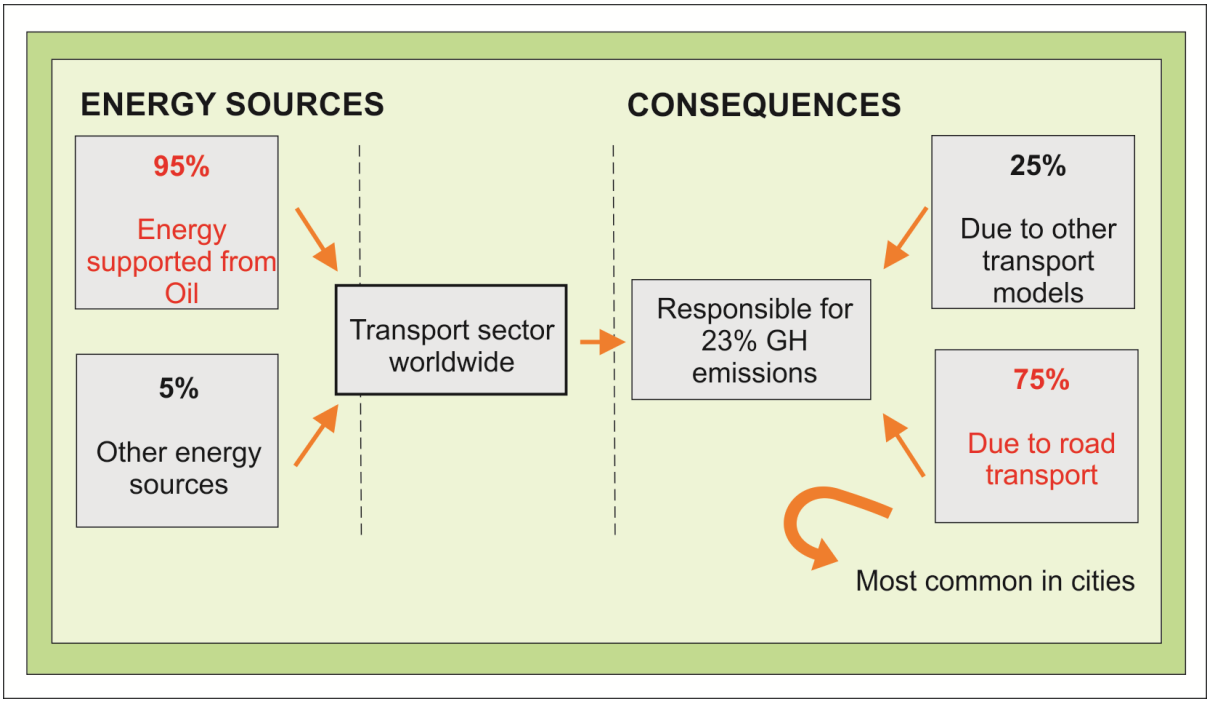
Main consequences of urban transport congestion would be delays, both in freight and passenger transport. This will cause money losses to the companies (because they will probably lose clients) and time losses for citizens.

2.2. Global Warming

Transport modes are closely related to way of life. Cities depend and are conditioned, in terms of spatial urbanization and way of life of its inhabitants, by transport networks.

Furthermore, transport sector plays a crucial and rising role in energy uses terms and GH (greenhouse) emissions in global strides.

Figure 2: Transport Global Impact



Source: own preparation based on Real Academia de Ingeniería (2009), p.43

The graph above highlight transport impact, both freight and passenger, in global terms. It is interesting the fact that road transport implies the greatest proportion in the GH emissions. Obviously this data is pertinent for our purpose because urban transport is almost completely composed by road transport. Furthermore, the volume of transport activity is expected to continue to grow throughout the years.

If nothing changes, in the worldwide transport trend, it is expected that in 2030 the global transport energy consumption will be 80% more than nowadays.[5] Thus, city transport planning has to take this information into account in order to develop an urban transport network sustainable and efficient, with the ultimate goal of reducing environmental global impact.

In addition to this, transport design also impacts directly in the industry, trade and tourism industry in particular, which without transport will means nothing.

Due to transport demand has a rising trend; the action line for a city that wants to be Smart has to be reaching the concept of "sustainable transport".

Sustainable transport

Ssustainable development is the development which satisfied current population needs without compromising the satisfaction capacity of the future generations needs.

Using the above definition, the ultimate goal of a transport policy in the Smart City must be: take actions for improving air quality and avoid a human and environmental disaster. Hence, the aim to stop transport negative effects (pollution) while its positive aspects are maintained, such as agility, convenience or efficiency.

European Commission has already created an action to reach this objective. New White book "Transport 2050"[6] demands a new aim for European countries: reducing greenhouse gases emission among 80% and 95% regarding data from 1990. This would be, if it is accomplished, a 60% reduction in transport pollution.

A reduction in transport pollution has been observed during last years. However, in some manner, this reduction can be considered as a consequence of the reduction in economic activity due to the European crises.

As a consequence of this, is obvious that a solution must be taken to decrease the impact of this problem.

2.3. Smart Cities

Before explaining what a Smart City is, it is necessary to understand better its performance. Smart cities' pillar is which is known as "Internet of things". It consists in two or more objects connected through a network. With this mechanism, users can obtain live data of the object and also manage it without the need of being close to it but with some device. The only

[5] Real Academia de Ingeniería (2009), p.44.
[6] Pedret, V. (2011).

requirement is to introduce an RFID chip (Radio-frequency identification), or any other wireless operator, in any object for allowing it to process and send information.

"Internet of Things" (IoT) is a revolution which can cause a social impact between 5 to 10 times greater than the one that emerges with the internet arrival", says John Chambers, Cisco's chief executive (one of the most important digital connectivity companies). This company estimates that in 2020 some 50.000 million things will be connected[7].

There is no doubt about the advantages that companies gain with IoT: having a real-time monitoring of products. However, main concern is lack of security. Internet security is lower every day that passes because the more connected devices, the greater cyber-attack possibilities are.

The concept

The "Smart City" concept has turned over into the futuristic multidisciplinary paradigm in the last decade. It guides design, planning and organization of cities and life inside them. It looks for sustainability, efficiency and organizational efficacy based on the use of "Information and communication technologies" (ICT or IT).

It emerges from the idea that managers of a city look for companies and citizens' welfare with the aim of seeking to an enhancement in the quality of life, an economic and environmental sustainable development and a participative government. However, by now the idea is being developed by large companies, State administration, telecommunication industry, etc. but with scarce public participation. In theory, The Smart City is unconnected with the Scale Economies and for that reason its procedure can be applied in both large metropolitan areas and medium size cities.

What makes possible the development of The Smart Cities is the phenomena known as "Globalization". "Globalization, with trade liberalization measures and fast technological changes altering the relations of production, distribution and consumption, has very substantial effects on city development"[8].

Although the term “Smart City” is not very widely used yet in spatial planning literature or urban research, the study conducted by *Markess International* (2012)[9] done in few cities define the three main features of the Smart Cities:

a) A fluent and interactive relationship among the users based on the continuous information flow through the IT that eases the services access to the users.
b) An optimized supervision of the city performing by the managers based on the social network and on the data transference.
c) New cooperation ways among networks and public/private managers, local/supra-local managers with the ultimate goal of building new cooperation and administration ways.

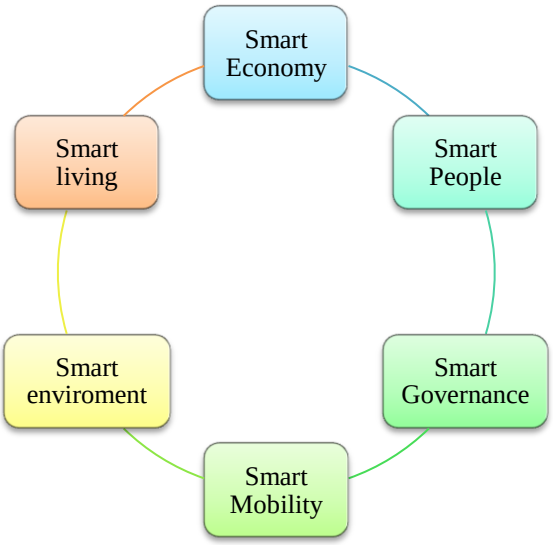
[7] 20 minutos.
[8] Giffinger, R, et al (2007), p.8.
[9] MARKESS International (2012).

In some manner, who manages the IT manages the system. Thus, it is not odd thinking that this position could be performed by the large companies, removing the spotlight from the State administration that gradually is losing power toward them.

It is expected that the large companies will be those who govern the cities and across them govern the societies. Nevertheless, documents available related to this topic (Smart Cities) make a special point in public participation and in citizen's compromise. At the moment The Smart City is showed as a concept linked with the logistics and the conjoint of technologies and procedures oriented to collaborate with the administration and the organization of some cities focused on decrease of the green houses gases emission, encouraging the use of renewable energies in order to create electricity, heat and air-conditioning and finally in the efficacy in the power consumption.

There are several fields related to the Smart City. Using the work "Smart cities - Ranking of European medium- sized cities", six characteristics of this kind of city can be defined as "the roof of the Smart City" in general terms:

Figure 3: Smart City Roof



Source: own preparation based on Giffinger, R et al. (2007), p. 13.

The target of our Master Thesis is the role of transport in the Smart Cities and how to manage it in an efficient way.

We can't afford the construction of a Smart City without looking to the transport network, being this part of a Smart City one of the most important, as we are going to explain therefore.

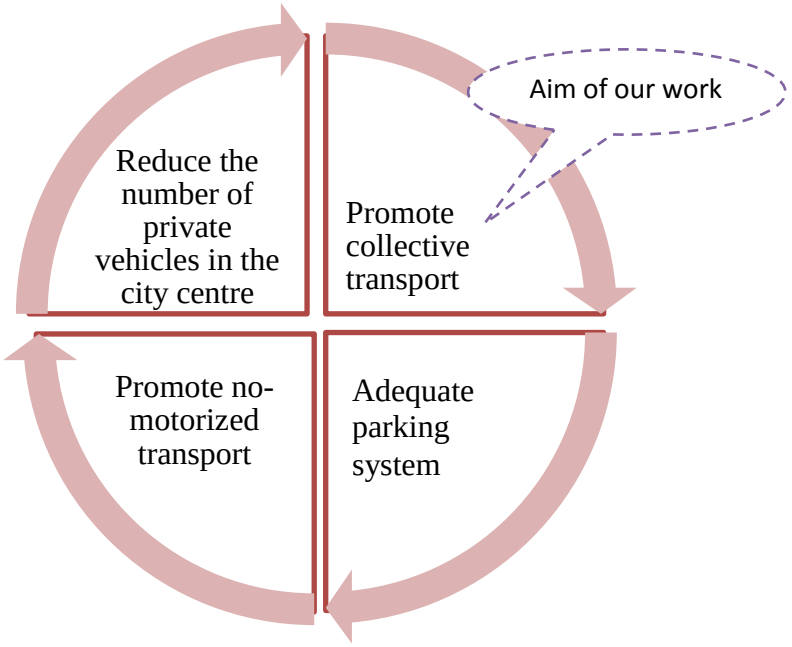
2.4. Role of transport in the Smart City: Smart Mobility[10]

It has been accepted worldwide that transport model which revolves around oil and private vehicle is totally outdated. The energy model which involves its production and its consumption is going to be a focus in the new mobility paradigm within Smart Cities.

Nevertheless, the most important thing is going to be an accurate urban planning, that will fit three main requirements: prevent citizens from doing large displacements, promote the use of public transport (bicycle and by foot) and increase vehicles efficiency. In addition, these three main requirements could be amplified with these two secondary objectives: guarantee better quality mobility options and improve the quality of live in the city by promoting less pollutant modes of transport while improving the quality of air[11].

Knowing this, what a city needs in order to define its action plan can be summarized like this:

Figure 4: General Goals of a Smart Mobility Strategy



Source: Own preparation based on G.I.S.T (2013), p. 10-11.

We have considered that, in order to introduce the Smart Mobility concept, which from now is going to be named as "SM", it is useful to briefly explain what the *Ranking of European medium-sized cities* is. Understanding what this ranking consider a important requirement to be a Smart City would help us to understand what the important features are.

[10] In this work our focus is **passenger transport in cities**. Thus, we are not going to talk about the freight transport in order to specify the focal point of this Master Thesis.
[11] G.I.S.T (2013), p.10.

Authors claim that this ranking is probably the best tool in order to compare one city with others for identifying its strengths and weaknesses in smart terms. To summarize, it is the best Benchmarking Smart City tool by now. It considers a huge range of indicators inherent to the concept of Smart City. In addition to that, this ranking is especially appropriate for our purpose because it is based in medium-sized European cities, like Las Palmas de Gran Canaria. The features considered by this work to classify a city such as a medium-size are the following:

Table 2: Essential features to be considered a Medium-Size City

Features	**Study range**	**LPGC[12] City**
Population	Between (100.000 , 500.000)	382.296 Inhabitants
Universities	At least 1	ULPGC [13]
Catchment area[14]	Less than 1.500,000	No bigger city control

Source: Own preparation based on Giffinger, R, et al. (2007), p.16.

The indicators which had been used to establish the cities' smart-degree in this study are plenty. They are related with all the 5 sectors that build the Smart City roof, which had been named in the previous section. In our case, only the Smart Mobility indicators are going to be taken into consideration.

***Main indicators of Smart Mobility*[15]**

Local accessibility

- Public transport network per inhabitant
- Satisfaction with access and quality to public transport

National and international accessibility

- Language variety

[12] "Las Palmas de Gran Canaria".
[13] "Universidad de Las Palmas de Gran Canaria".
[14] To exclude cities which are dominated by other cities.
[15] Giffinger, R, et al. (2007), p.25.

Availability of IT-infrastructure

- Computers in households
- Broadband internet access in households

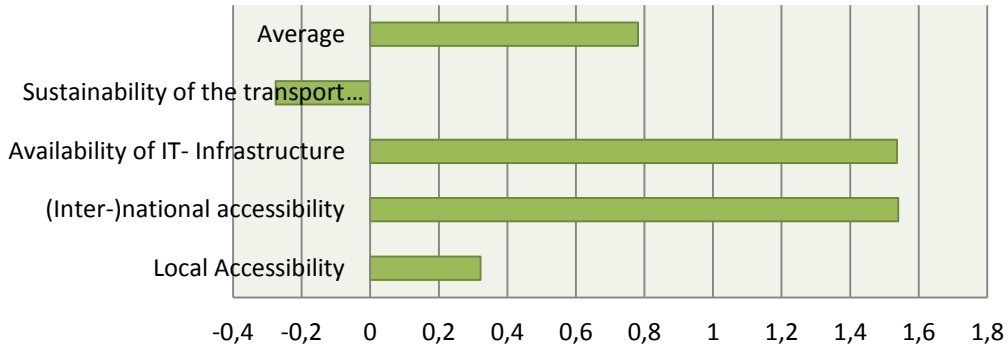
Sustainable, innovative and safe transport systems

- Green mobility share (non-motorized individual traffic)
- Traffic safety
- Use of economical cars

This list done by the official European Ranking is useful to classify a city depending on if it is considered more or less smart than others in mobility terms depending on the degree of compliance with the above requirements.

According to this ranking, the city of Eindhoven, Netherlands, has the first position if we consider the SM development.

Figure 5: Eindenhoven (NL) Smart Mobility

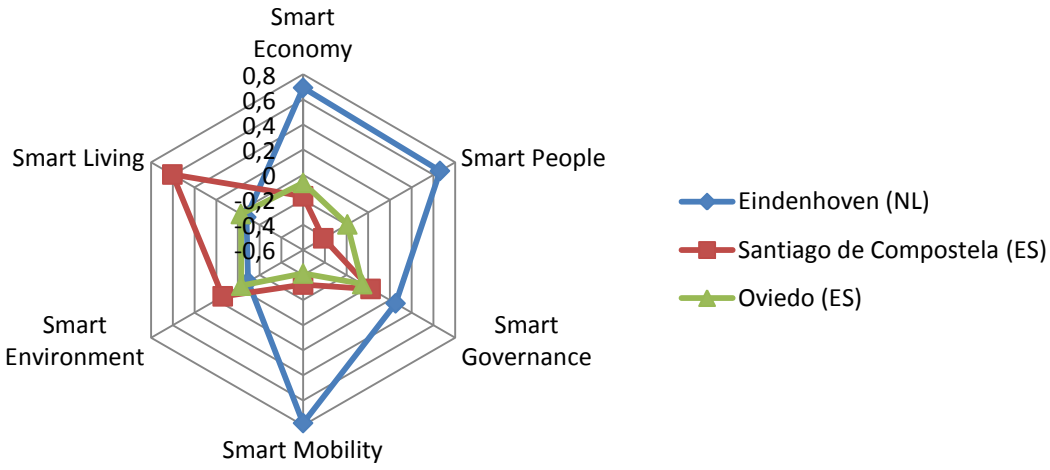


	Local Accessibility	(Inter-)national accessibility	Availability of IT-Infrastructure	Sustainability of the transport system	Average
Eindenhoven (NL) Smart Mobility	0,322	1,54	1,537	-0,276	0,781

Source: Own preparation based on *http://www.smart-cities.eu/*

This ranking allows us to make a comparison between the city which has SM highest degree with two Spanish cities included in the ranking. As we can see, Spain has already got a lengthy path ahead. Oviedo and Santiago de Compostela are very similar between them but a huge difference is between these two and Eindenhoven.

Figure 6: Benchmarking



Source: Own preparation obtained from *http://www.smart-cities.eu/*

2.5. Collective transport modes: Santander successful case

Santander has turned into one of the examples of Smart City worldwide in not much time. Based on its "Plan Director de Innovación", Santander is going to be in the short term an enormous platform capable to offer fitted solutions to citizens and business by capturing data, treating them and its posterior spread.

That is why the example of Santander Smart mobility, more specifically Santander Smart Public Transport, is going to be used as the baseline of any great public transport design. Objectives for different modes of transport have been established in their action plan. However, in this work only the objectives related with collective transport are going to be used.

Table 3: General Criteria of Collective Transport	
Networks integration	Despite collective transport has to circulate with the private transport, efforts need to be made in order to segregate collective transport for reducing frictions between them.

Accessibility	The network has to be accessible for everyone.
Related	The network has to be expanded throughout the territory enabling and easing transfers between different modes of transport.
Connectivity	The network has to allow the user to make the maximum number of transfers in the same mode of collective transport.
Better service quality	Collective transport has to try to copy the duration of any trip if it is done in private vehicle. In addition, things like commodity and information are key elements for choosing or not a collective transport mode.

Source: Ayuntamiento de Santander (No date).

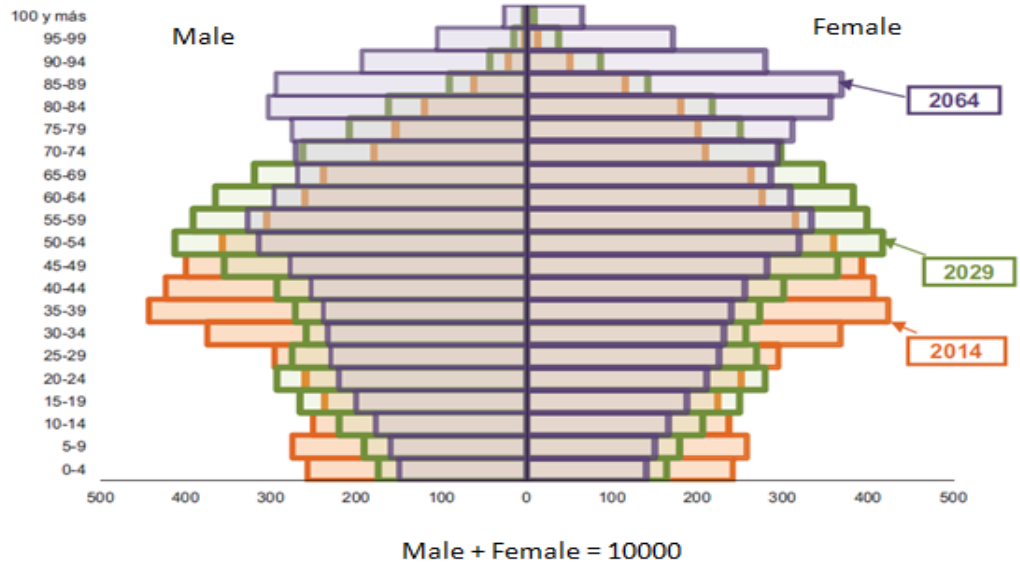
3. SPAIN AND LAS PALMAS DE GRAN CANARIA[16]

3.1. Population trends: ageing society and urban concentration in Spain

Ageing tendency of Spanish population during last decades has been greater than in the rest of industrialized countries. The United Nations projects that population over sixty years old will exceed 40% of total Spanish population in 2050, becoming the oldest country in the world[17].

It is projected that in the next 15 years Spanish population decreases in 1.1 million people due fundamentally to birth rate decrease, mortality rate increase (which will surpass the birth rate in 2015 according to the predictions), and to the difference in the migration balance.

Figure 7: Spanish Population pyramid

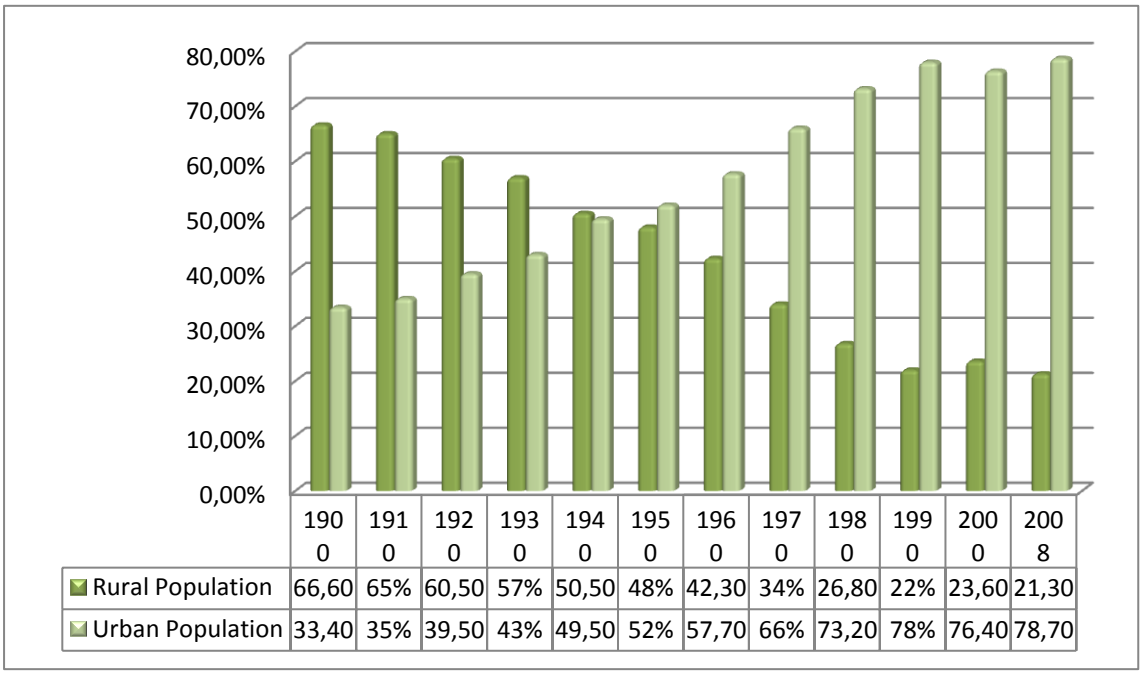


Source: INE (2014), p. 7.

Spanish population has experienced a redistribution characterised by concentration in cities and rural exodus during last decades of twentieth century. Population has moved to the most actively economic regions, Madrid and Barcelona, and to coastal regions attracted by touristic activity, especially Mediterranean coast and the two Spanish archipelagos. Central Spain has been gradually uninhabited.

[16] From now LPA_GC is going to be used instead of Las Palmas de Gran Canaria.
[17] Fernández, J.L. et al (No date).

Figure 8: Urban and Rural Spanish Population Distribution 1900-2008



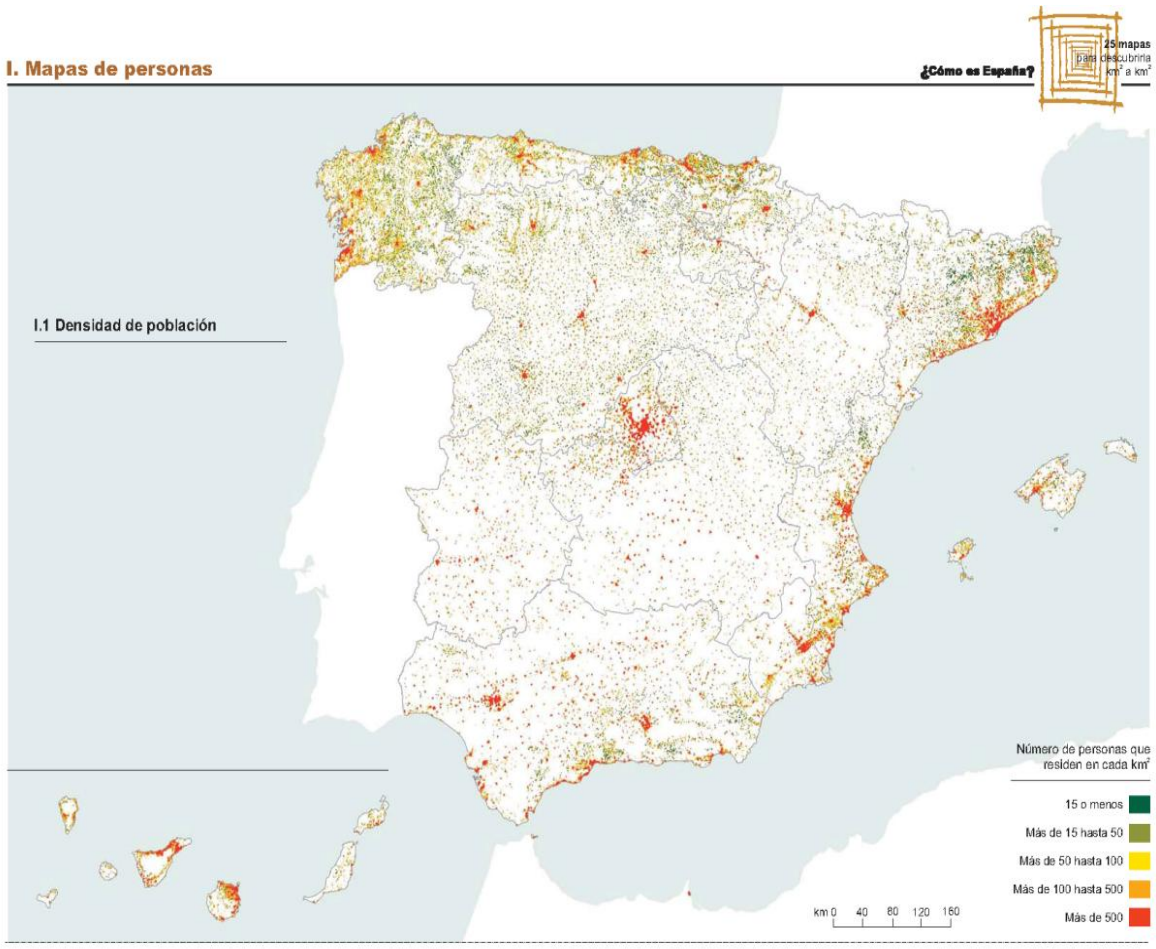
	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2008
Rural Population	66,60	65%	60,50	57%	50,50	48%	42,30	34%	26,80	22%	23,60	21,30
Urban Population	33,40	35%	39,50	43%	49,50	52%	57,70	66%	73,20	78%	76,40	78,70

Source: INE (2008).

Nowadays (2014), Spanish population, which amounts more than 46.5 million inhabitants[18], is distributed as following: only 8 Autonomous Communities out of 18, in addition to the two Autonomous Cities, concentrate 77.3% of total population. Comunidad de Madrid and Cataluña, two of the 7 Autonomous Communities mentioned before, concentrate 29.6% of total population in the whole State. Andalusia concentrates the greater number of inhabitants in Spain, 8.390.723 in 2014 (18.04% of the whole population). 1.1 million people belongs to The Balearic Islands and 2.1 million people belongs to The Canary Islands.

[18] INE (2014), p. 2.

Figure 9: Population Density in Spain



Source: INE (2011), p.4.

In a close temporary horizon, concentration in cities trend will do nothing more than increase, while interior Spain will continue losing its population. This means that population in big cities will raise over time.

3.2. Las Palmas de Gran Canaria

Based on the Real Academia Española, a city is defined as a conjoint of streets and buildings controlled by a City Council, in which its numerous and dense population works, in general, in activities that have no relation with the agriculture sector.

First of all we are doing a brief description of Las Palmas de Gran Canaria. It has 382.283 inhabitants (ISTAC, 2014), 3801,92 inhabitants/km^2 (Wikipedia, Las Palmas de Gran Canaria), and the municipality sizes around 105.55km2 (Wikipedia, Las Palmas de Gran Canaria). Las Palmas de Gran Canaria, with Santa Cruz de Tenerife, plays an important role in The Canary Islands' economy. It depicts in industrial sector, trade and tourism. It allows a constant flow of goods and people through the port (La Luz port was considered in 2013 as the fourth most important port in Spain) and airport.

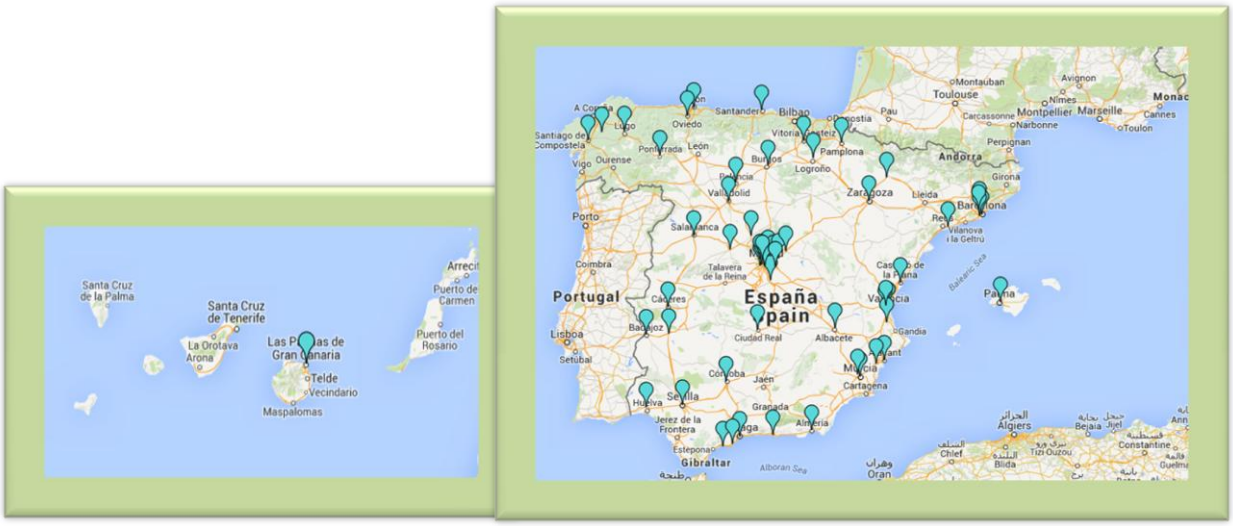
Figure 10: Situation of Las Palmas de Gran Canaria

Nowadays, many cities have evolved into Smart Cities. One Spanish city, Barcelona, has been ranked with the first position in Smart Cities Global Ranking, elaborated by Juniper Research, above cities like New York and London[19].

Nevertheles, Barcelona is not the only Spanish city recognised as a Smart City. According to *Red Española de Ciudades Inteligentes*[20] (RECI), 60 cities form this network. LPA_GC is one of them. The aim of this association is sharing information and experiences, with the last goal of reaching an automatic and efficient management of the infrastructures and urban services so that they can offer a better quality of life to the citizens. In the following map the cities that form this association are represented.

[19] El Mundo.
[20] Spanish Smart Cities Network.

Figure 11: Spanish Smart Cities Network



Source: www.redciudadesinteligentes.es/

Technology use in a city influences several aspects of it. In this work, the effects that technology has in relation with the mobility within the city, and, because of the mobility, the effects that it has in relation with the environment are going to be discussed.

The IT not only are conformed as auxiliary tools for the management improvement of the city, but as essential elements of a city strategy in the medium term and in its future action line: the cities are going to have these IT in all the aspects that conform a city with the aim of reassuring its sustainability in the long term., turning into real Smart Cities.

LPA_GC has defined its own Smart vision based on 4 pillars, which are their objectives[21].

1. **Sea tourism**

Medium-high Smart Degree

- Attract tourists from new markets and increase the average expenditure per tourist.
- Being a "quality destination" in order to be different from the rest of the island.
- Promote beaches and water sports enjoyment.

2. **Mobility**

Medium-high Smart Degree

- Cost optimization and inclusion of all public transports modes.
- Inclusion of all public transports modes under the same method of payment.

[21] Ayuntamiento de Las Palmas de Gran Canaria (no date; a), p. 13.

3. Urban services
Medium-low Smart Degree

- Promote interoperability with other municipal services.
- Urban services management computerization.
- Promote municipal regulations that improve energetic efficiency.

4. **E-Government**
Medium Smart Degree

- Development of interoperable and information- share cross-platforms for the full process of the Electronic Administration.
- Services homogeneity and higher quality in the services offered to the citizens.

Smart City path

Taking the previous four pillars into account, LPA_GC, trough the City Council, has developed several advances in City Intelligence terms. What is more, LPA_GC has lots of projects, which are going to be named in table 5.

Table 4: Actions taken by the City Council in Smart Terms
Applications
- LPA Avisa: Introduced in 2013, its utility is reporting incidences in street furniture of the capital that specialists receive and try to fix. Then, the citizen is informed trough the application of the fix process state. - LPA Park: Also introduced in 2013. In less than one year more than 100.000 parking operations were conducted by this application. It serves for paying the Regulated Parking Area without both movement and cash but trough the app. - LPA Accesible: It identifies both handicapped accessible and not accessible points. This is useful for the Local Authorities, in order to develop an accessible data base for improving city accessibility, and for the citizens due to the planning that they could make before going out and for reporting problems directly to the Local Authorities across the app. - LPA Visit: It contains all touristic information available of the city, with the advantage of no Wifi requirement .

Digital signature and integrated tax administration
It speeds up all the citizens' procedures and allows virtual communication with Treasury and reduces waiting time. The digital signature reduces costs in terms of human resources, paperwork and times.
LPA_GC Smart Destination
The conjoint of IT plus tourism. LPA_GC receive the first "touristic demonstration centre" which is formed by tools kike information systems to know the tourist's behaviour, intelligent touristic offices... Furthermore, The Touristic House which has several applications to improve the informatics' channels that the tourist have.
On-line certificates of residence, on-line plenum-watching and participation virtual gateway
With the on-line certificate of residence there is no need to move to an office in order to obtain it (process' speed-up). The possibility of plenum-watching creates a closer relationship among the government and citizens. The participation virtual gateway, allows "popular vote" by internet for issues such as the Carnival motive.
Other proceedings
- Wifi scope amplification - Open Data gateway: allows some public services (Guaguas Municipales, Traffic, Accessibility...) to provide citizens with interesting and useful information but with the last foal that the technological sector could make applications and software from this information.

Source: Ayuntamiento de Las Palmas de Gran Canaria (no date;a), p. 18-26.

Table 5: Smart Projects in LPA_GC			
	High priority	**Medium Priority**	**Low priority**
High complexity	Services digitalization and LPA Mobility App.	Innovation engines, citizens adaptation to IT.	Intelligent parks and gardens.
Medium complexity	Citizen CRM (Customer Relationship Management) and citizens participation.	Transparency gateway.	Information use supervision and waste disposal service transformation.
Low complexity	Smart Destiny and Paperless administration.	Digital commerce, energetic efficient services.	Knowledge management.

Source: Ayuntamiento de Las Palmas de Gran Canaria (no date; a), p. 35.

3.3. LPA_GC Mobility

It is essential to explain what the collective transport offer in the city is and what its current situation is. In this work, data supplied by the City Council in the document "LPA_GC Movilidad en Transformación"[22] has been taken as the reference data source, because these are the most recent and reliable data.

[22] Ayuntamiento de Las Palmas de Gran Canaria (no date; b).

The distribution is the following:

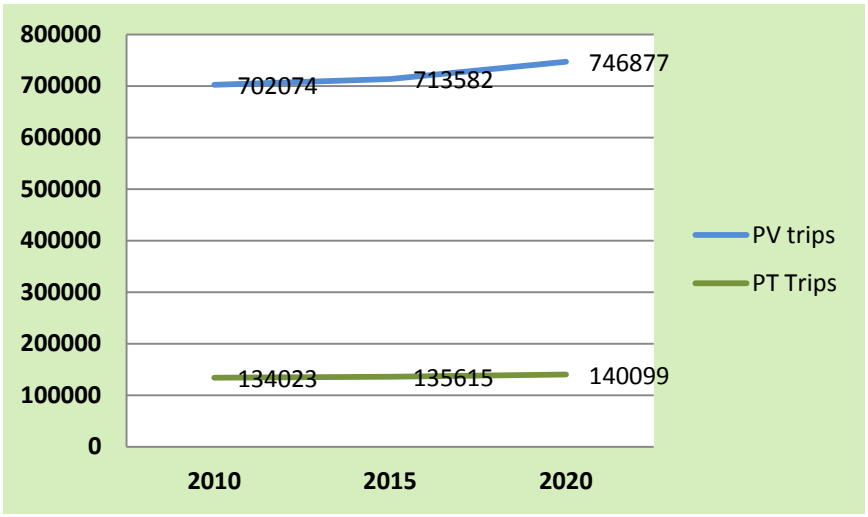
Table 6: Transport Modes Distribution within the City		
	Total Trips	**Intra- municipal trips**
Private vehicle	67.0%	66.3%
Public Transport Trips	13.0%	13.2%
Foot trips	15.1%	15.6%
Bicycle Trips	0.4%	0.5%
Taxi and others	4.5%	4.4%

Source: Ayuntamiento de Las Palmas de Gran Canaria (no date; b), p. 10.

The private vehicle is the most used by the population of Las Palmas, being 17% more than the half of all the transport modes. The second position is for the Public Transport trips (13%), followed by foot trips. These are the date related to the trips that the citizens of Las Palmas make. However, when we talk about the trips that they made into de city, the percentages does not differ much. The ranking is the same, first private vehicle (66.3%), second Public Transport trips (13.2%) and third foot trips (15.6%).

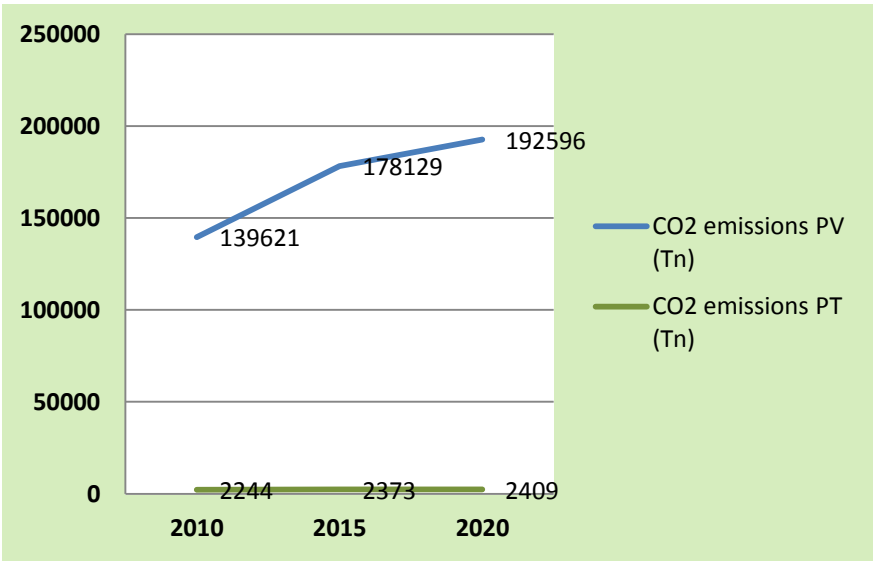
Being the private vehicle, as we have just seen, the most important transport mode, some statistics has been done in order to know what do we have to expect and, from there, what are the changes that have to be done to achieve a more sustainable and efficient transport network.

Figure 12: Private Vehicle (PV) VS Public Transport (PT) Expectancy



Source: Ayuntamiento de Las Palmas de Gran Canaria (no date), p. 14-15.

Figure 13: Private Vehicle (PV) VS Public Transport (PT) Emissions Expectancy



Source: Ayuntamiento de Las Palmas de Gran Canaria (no date), p. 14-15.

The conclusion obtained by simply looking at these graphs is that, first, the use of private vehicle is expected to be more and more every year. Second, the environmental impact of this rising trend will be huge. The more private vehicles, the more pollution.

However, the reason that explains why the PV is such higher in comparison to the rest of transport modes is that not only the territorial planning but the transport network favoured its over-use in Las Palmas City.

The disadvantages of the increasing number of private vehicles are more than pollution. In general terms, the private vehicle is the mode of transport that generates more pollution, the most expensive one and the one which needs more energy[23]**.** Some of them are environmental problems, social and economic problems and health problems for the citizens.

For now, we have the required knowledge to have an idea of why actions need to be taken by the institutions in order to address problems mentioned before; population trends (both population ageing and cities overcrowding) and urban transport congestion looking always toward the Smart City model.

Now, let's briefly explain what have been the actions taken by the City Council in order to improve the mobility in the city. In addition, future projects in Smart Mobility are going to be showed.

Table 7: Actions taken by the City Council in Smart Mobility terms	
Buses	- Itinerary changes and improvements related to the service quality and to the frequencies. - Introduction of free transhipment. - Real-time information panels in bus stops that inform about frequencies. - Better services (more frequencies) to the University. - Nigh services. Buses called "Lunas". - Improvement on the vehicles quality. - Contactless card as method of payment. - Infrastructures improvement. - App (aplication) for smartphones and web.

[23] Ecologistas en acción.

	- New website. - Visual and sonic information systems inside buses.
Bicycles	- Bike party on Sundays - Teacher training at schools to teach children about the importance of the bicycle use. - Current bicycles lines but with problems. Improvement of bicycle lines. - 30 zones. Areas in which cars can only drive at 30 km/h, easing the bike use in these areas. Expand areas like this is a proposal. - Public bike system (SBP).
Parking	- Parking places increment. - Price reduction for the parking place in 50% for residents. - Weekly/monthly bonus. - Application (LPA park) to pay the Blue Zone (payment parking places in the street) across it, with no cash. - Intermodal parking "El rincón" which promote the use of public transport within the city while the car is parked in this place (4.000 parking places).
Taxis	- New legal framework to avoid illicit practices. - Fleet uniformity and modernization to improve the image. - GPS systems in vehicles to improve drivers security. - Control of polluting substances..

Source: Ayuntamiento de Las Palmas de Gran Canaria (no date; b), p. 27-45.

Table 8: Smart Mobility Projects in LPA_GC
Bus Rapid Transit (BRT): High capacity public transport system.
It is expected to be established in greatest demand zones. It is a similar system as the tram, but covered by buses. It has an exclusive platform and reserved line, traffic lights priority. All of these with low costs. Vehicles are expected to have capacity for 170-190 passengers.

Source: Ayuntamiento de Las Palmas de Gran Canaria (no date; b), p. 53-56.

4. MODEL

Once we have explained the theoretical framework in which our work is based and the current situation of Las Palmas de Gran Canaria in terms of Smart Mobility is time for explaining what our model is going to improve in mobility terms.

In some manner, our proposal tries to decrease urban congestion by the use of IT while reducing the use of petrol energy which generates lots of pollutant gases that finally impacts on citizens' quality of life.

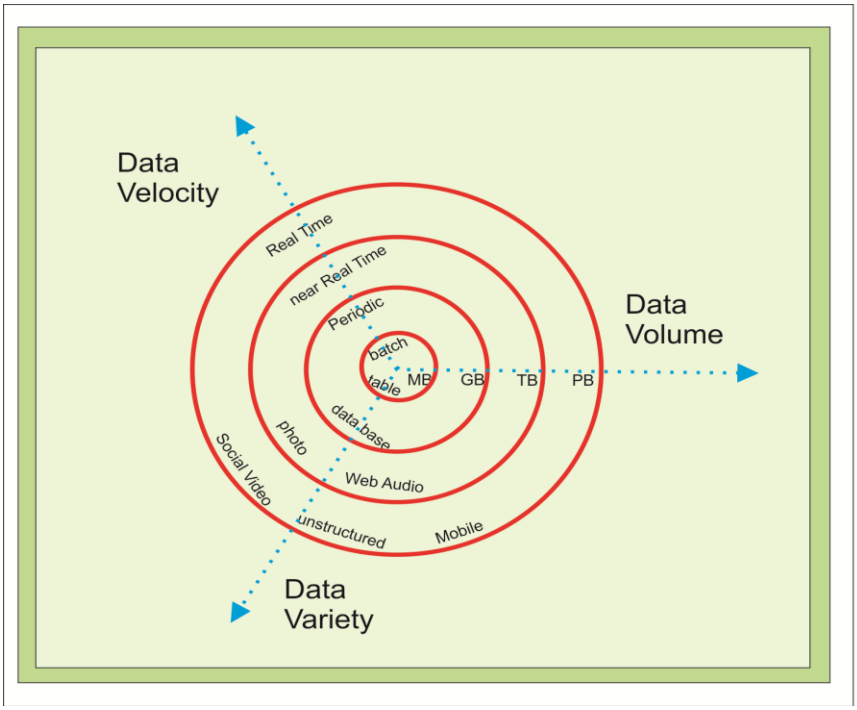
4.1. Bases

Big data is generally understood as an impressive amount of data (structured, not structured or semi-structured) which is collected and that would be impossible to upload and understand using traditional methods. So, Big Data label is applied to all information that cannot be processed or analyzed with traditional tools[24].

Data coming into Big Data needs to be classified and actually it is following 3Vs theory[25]:

- Volume: amount of data.
- Velocity: how fast data is collected and structured.
- Variety: different data sources.

Figure 14: 3Vs of Big Data



Source: Own preparation based on Data Science Central.

[24] IBM DeveloperWork.
[25] Some discussion exists related to this topic. Some researchers support 3Vs theory and others 4Vs theory. We have chosen 3 VS theory in our work.

"Instituto de Marketing online" classifies the variety of data in three groups:

People to people (P2P): data collected by the communications among people. For example emails sent, Youtube and Facebook uploads, Tweets sent, Web Blogs and so on.

People to Machine (P2M): Information collected by E-commerce, Bank Cards, computers and websites visited, Mobiles, Digital TV and more. It is called P2P because is the interaction between people and machines. People turns on the computer and buy something specific.

Machine to Machine (M2M): In contrast to the above relation, in this case people do not do anything. It is a relation among machines. This is our case. Table 9 shows a summary of different devices used to collect data through this M2M process.

By itself, data does not generate information. It is the treatment of data which generates useful information. It is here when technology and intelligence have to joint in order to create a Smart Solution.

These sensors are the first step in every IoT process[26]. An impressive amount of information is gathered across them (Data Collection) for then being sent to a virtual platform, normally called Big Data platform, that organizes them (Data Processing) making possible its use to predict and manage urban fluxes for finally boost the intelligent management of the city[27].

Table 9: Summary of most common sensors that a city could have to improve its transport system[28]
Espiras
This type of sensor could measure intensity, occupation, speed and classification of vehicles.
CCTV (Closed Circuit Television)
It is a circuit of cameras all around the city which its main purpose is control different activities and events, such as football matches, strikes and so on.

[26] IoT concept explained in point 2.3.
[27] Universitat Politécnica de Catalunya (no date), p. 7.

Example 1: In the case of SM the CCTV could be used to control the traffic flow in real time, with the possibility of knowing where congestion are and what is the best option to avoid it. Example 2: In addition, not only traffic flow congestion, but people congestion could be used to redirect the traffic to satisfy the demand in each moment (This will be treated deeper later on).
LPR (License Plate Reader), antenna for capturing Bluetooth / WiFi devices and electronic readers called TAGs
All these technologies allow calculate travel time among consecutive units. Antennas capture the signal of each unit if the unit has WiFi / Bluetooth connection (like a Smart Phone or Navigator). This will permit know where a unit (vehicle) is in each moment. RFID tags are little devices that looks like a sticker which are placed in an object, in this case cars, and contain antennas connected to an RFID (Radio Frequency Identification) emitter or receptor. This allows communication between the object and the emitter/receptor with the advantage of, for example, crossing road tools without stopping (because your Tag is prepared to pay automatically) or entering in a garage without stopping to pay because your car is automatically recognised. LPRs help managers of the city to know, for example, car park usage, pedestrian crossing usage, number of vehicles along the road, areas of low and high congestion, frequency, location and cause of road works. Obviously, this tool (LPR) needs a CCTV system. If cameras don't exist, licenses plates could not be identified.
GPS (Global Positioning System)
GPS has lots of applications within a Smart City. It is used to know where the vehicles are positioned. But... what kind of vehicles? It allows knowing the position of any vehicle that has a GPS installed. Knowing this it is possible to know the route or routes that it has taken. Not only for private vehicles but for public transport such as buses or taxis.

Source: Wikipedia (a;b and c).

A real example of a city which uses these sensors is Barcelona. To feed their data platform they installed numerous sensors throughout the city. 116 espiras, 15 Bluethooth antennas, RFID Tags and GPS. Using these devices, Barcelona made a simulation in the area of Ensanche barcelonés, which due to its dimensions and traffic flow can be equipped to a

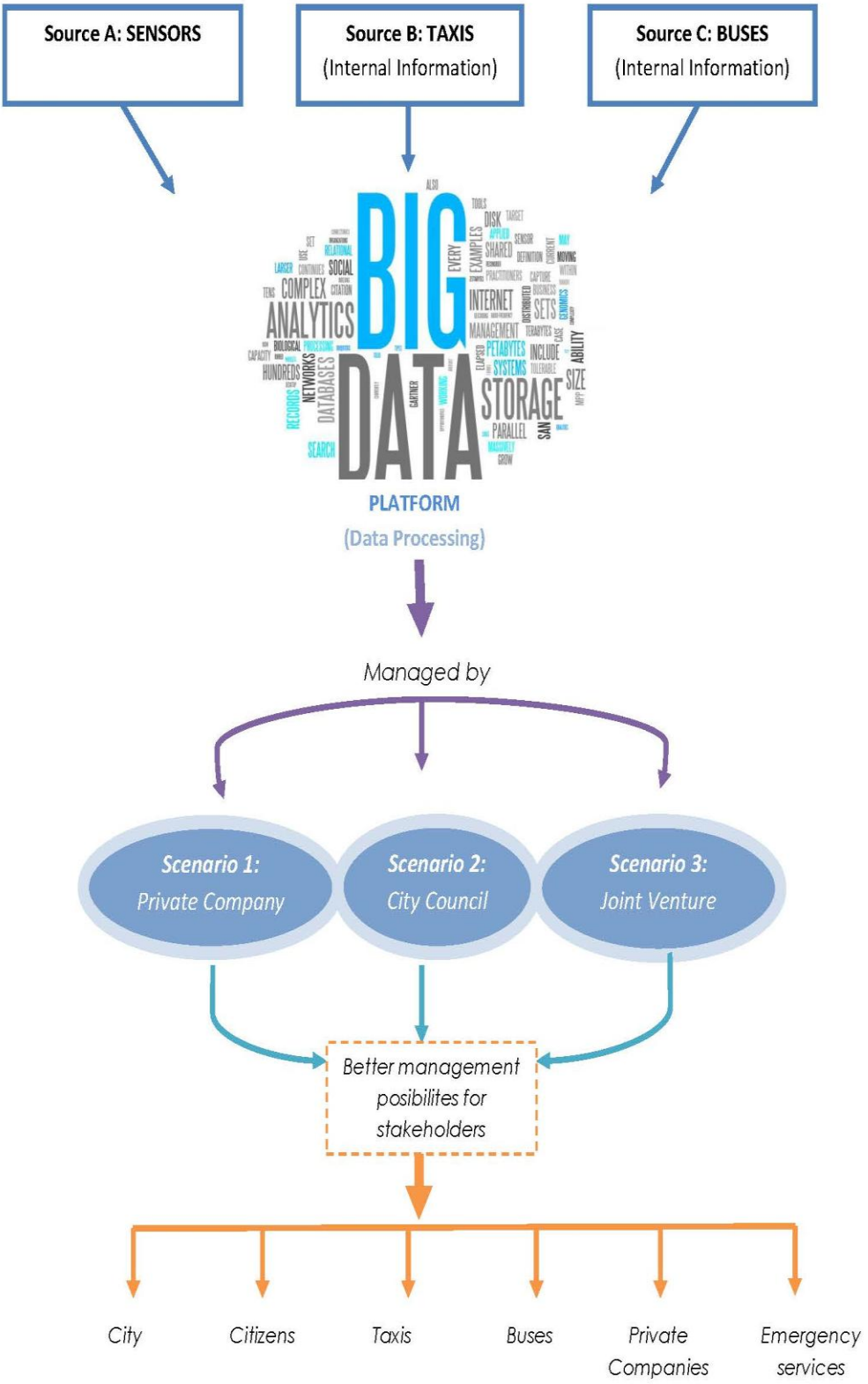
medium-sized Spanish city. The simulation was successful. They demonstrate that the model they used was robust and the results were reliable[29]. This is an old project in Barcelona (2013). Now, it is the most important Smart City in the world according to Juniper Research (2015). Being aware of this, it is clear that this example is the first step that any city which wants to excel in Smartness has to follow.

4.2.Proposal

We have been explaining the basic performance of a Smart Mobility model within the Smart City, but now is the moment to apply all which have been pointed out to Las Palmas de Gran Canaria Mobility. Linking the information of the current situation of transport in LPA_GC with the bases of any SM mobility model and the change from a Push model to a Pull transport model the following figure explains the performance of what could be the dynamic in LPA_GC if the city follows the logical steps.

[29] El País.

Figure 15: Smart Mobility model



Source: own preparation.

Data sources

In the graph above three blue arrows show the influx of open/raw data into the platform. We have talked about data coming from sensors, (**Source A**), but not about data coming from internal information of Taxis and Buses. In spite of this differentiation, all data comes from Machine to Machine procedure.

Taxis and Buses are the only public transport in LPA_GC. For this reason only their internal data can be added to the Big Data platform. First, let's explain how these two modes of public transport work for understanding what kind of information would be useful for the model.

Source B: Taxis

In the island of Gran Canaria taxi service is divided by municipalities. In other words, LPA_GC has their own taxis with permissions to do services in the city of LPA_GC. The city has 1.640 taxi licenses, which suppose one taxi per 230 neighbours. Only Madrid, Barcelona and Santa Cruz de Tenerife have more taxis per inhabitant. Therefore, LPA_GC is the fourth city in Spain in terms of taxis per inhabitant[30].

Taxi Radio Gran Canaria (Taragranca) is a cooperative formed by 7 municipalities, being Las Palmas de Gran Canaria one of them. This cooperative has an important technological base. A taxi can be solicited by citizens in different ways:

- By the App Taragranca "TaxiClick"

  - Possibility of knowing where the taxi is in each moment since the order
  - Possibility of being able to know the type of vehicle that is going to do the service
  - Possibility of choosing an adapted vehicle for handicap people
  - Possibility of paying with credit card

- By the website www.taragranca.org
- By SMS
- By telephone
- Stopping a taxi in the street

The fact of being a cooperative implies that they work internally. Information collected by taxi service will be really interesting to construct a smart mobility model. Furthermore, the huge rate of taxis per inhabitant that LPA_GC has is another reason why taxis could collect a lot of urban transport information.

Information of interest

- Information of the whole service that a taxi does in a day and following days.
- Knowing this, for example, places where taxis do more services could be identified and points where taxis do not normally go could also be identified.
- Most frequent routes done by taxi drivers.
- Identification of traffic jams and accidents, because there are always taxis in streets so it is like a 24 hours service of traffic information.

[30] http:// www.taragranca.org

- Crowded or empty areas.

All these information could be easily collected by M2M technology. A GPS could provide geographic positioning in seconds and, if the taxis fleet is provided with this kind of devices, it would not be too difficult to generate a positioning map, indicating traffic problems or retentions to the switchboard. For this reason, information collected by taxis would be a big help to the Big Data platform.

Dynamic and real time information could be provided by taxis, in addition to sensors distributed throughout the city.

Source C: Buses

The above appliance of M2M for taxis could be the same in the case of public buses. As well as taxis, buses are circulating almost 24 hours across the city. The only difference among the information that taxis could provide to the model with the information that buses could provide is that buses have their static routes, which could only permit collecting information in the same places. When some special event is celebrated buses increase the frequency of the service, but normally through the same lanes. Taxis change their route depending on traffic state and also in special events so, in some manner, they cover a greater surface than buses. However, it would be useful to collect information from these two modes of public transport.

Bus system in the island of Gran Canaria works separately if the trip is urban or if it is inter-urban. The company called Global is in charge of the inter-urban trips. It was created in 2000 by the fusion of Salcai (in charge of southern area) and Utinsa (in charge of the northern area). Apart from this, the company called Guaguas Municipales brings the service within the city of LPA_GC and it is a public company since 1979. Both Global and Guaguas Municipales are into the buses cooperative called Autoridad Única de Transporte de Gran Canaria, which is formed also by other little private buses companies which provide service to little towns.

The great problem in Gran Canaria is that, because two different companies are in charge of the inter-urban and urban transport, and in spite of being part of the same cooperative, they use different applications to calculate routes. In other words, citizens can calculate their route within the city using the application of Guaguas Municipales but, if you want to calculate your route from the city centre to a town out of the city it would be impossible. You would need to use the application of Global to calculate your route out of the city, which means double effort and not an efficient system at all.

The only thing that the two companies have done through this cooperative, which obviously does not solve the problem at all, is creating a bonus card which allows only people of certain suburbs to combine both services with the same bonus card and always within the municipality area of LPA_GC[31].

Nevertheless, in our work we are not going to focus in this kind of interoperability problem because it is not the idea of the work. Our focus will be urban transport, which means that we are going to analyze the current situation of Guaguas Municipales.

[31] http://www.guaguas.com

It is formed by 242 vehicles, 40 lanes (37 diurnal and 3 nocturnal). In addition, there are 746 bus stops which are operative 365 days a year[32].

This company has its own application which allows the customer to know the buses frequency, bus stops list and nearest bus stop, different routes across the city and more. It is disposable for smart phones and in the website.

In addition, in 2014 they developed their contactless bonus card which eases the payment in buses but also could allow the company to know which routes is taken by each passenger. Guaguas Municipales has also a big presence in social network, communicating all news they have. However, the service of this public urban company, which means that it is controlled by the City Council, could be improved with the application of our model if this company gives their internal data to the Big Data platform.

Information of interest

- Slowest and fastest routes and reasons for why is it like that.
- Origin and destiny of customers by using the information provided by contactless bonus card.
- Most crowded routes.
- Most crowded bus stops.

Big Data Platform

Once the information sources have been identified, let's start explaining what the purpose of collecting the information is.

Raw data, or Open Data, is transferred from these sources to the Big Data platform. Information collected by sensors is commonly known as Open Data and it has been proved that lots of possibilities for business generation around open data in specific ecosystem, Smart Cities, exist. Information collected by sensors needs to be treated. Well processed data in the cities is the key for the smart services, is like the money for the commerce. Without data the services will not be smart, they will be just services[33].

The process occurred in a Big Data platform following in some manner this pattern: data enters in the Big Data in form of raw data. Once the data is entering in the platform a process known as Extract, Transform and Load (ETL)[34] is in charge of filtering data, removing outliers and recovering lack of data needed. Then, data goes to another data base called Data Warehouse. Here, data is both integrated and separated in order to create information that could be consulted and analysed.

After this process, data is correctly organized to use it for, for example, creating new applications which ease the life of the citizens. However, not only applications are the utility of collecting and converting data. In the following paragraphs what could be done with this information and who is going to benefit from it will be explained.

[32] http://www.guaguas.com/laempresa
[33] Miguel García (2015), p. 4.
[34] Wikipedia(d).

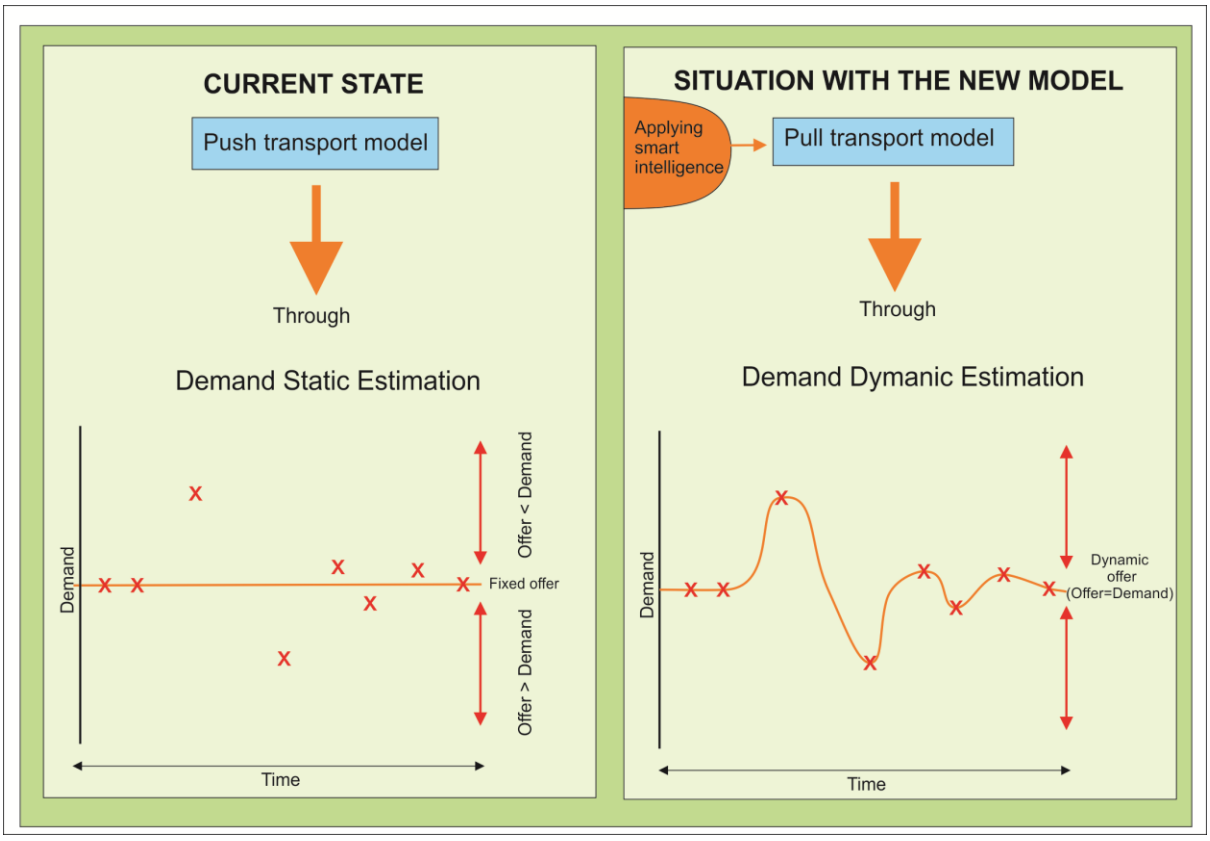
5. STAKEHOLDERS AND BENEFITS

Our model is like a new transport paradigm. The change from a Push transport model to a Pull transport model. Using data obtained by sensors and organized by the virtual platform will allow managers of the transport system to adapt transport offer to the demand in real time.

What is known as a **Push Model** is when the strategy of a company looks toward the distribution channels. In other words, when is the company who establishes the amount of good or service that needs to be consumed. If all the product or the service that the company planned is not consumed, the company would have stock and vice versa. If all goods or services that the company planned are consumed and the demand is requiring more, the company would have stock shortages.

This is how the transport system works nowadays in LPA_GC. They use **Static Estimations of demand**, which means considering no temporary variation in the demand trend after the moment it has been calculated and, by the way, any modifications in the service during a normal period.

Figure 16: comparison between current situation VS situation with the new model



Source: own preparation.

The aim of a Smart Collective Transport system is to be a **Pull Model**. Pull Models are those in which is the distribution channel, in our case users of collective transport, what determines the level of the service or good. In this case the company will be passive until the demand asks for the service or good. This could be applied in transport networks by using **Dynamic Estimation of demand**. Now the service or product, in our case collective transport service, is subjected to demand requirements. If the demand is higher, the service transport will increase its frequency or capacity to absorb the demand peak and, if by the contrary the demand decrease, the service will reduce its frequency or capacity.

The whole city will see repercussions of this model if it is implanted. A less congested and better organized city would emerge from traffic optimization. For this, pollution levels of the city would be less, because the traffic would be better organized and, in special, because the improvement in public urban transports management would generate a great impact in the environment due to the fact that it is a non-stop service.

Thereupon, is exposed a list of benefits, separated by each stakeholder[35], that this model would suppose if it is implemented[36].

Taxis

As it has been explained at the beginning of this paragraph, the change from a Push model to a Pull one would suppose a better adaptation of the urban transports to the demand.

If taxis service use the information obtained from sensors distributed throughout the city, for example cameras which detects clumps, and also from its own information as we named in point 4.2, their service could be much better than now. In other words, if each taxi stand has a camera which detects the number of people there and immediately this camera send a signal to taxis in order to cover that demand. In this way, taxis would be redirected to the point that needs to be satisfied, making clients happy with the service. This "method" could be used not only in taxis stands but in streets. When some clumps are detected in specific places cameras would also send a signal and redirect taxi traffic to the point. In this case, it would also save clients' time and energy because they would not need to use the application or calling taxi service because they would be there before clients have thought in calling one.

It will suppose a benefit both for clients and for the taxi company because it would reduce costs in terms of energy needed to run their vehicles. It would also make the service more efficient and taxi drivers will count with perfect information, not as before.

The ideal thing would be a taxi cooperative in the whole territory, in Gran Canaria. Doing this the service will be more efficient because the above system of taxis' redirection depending on the conditions of the traffic and clumps would be more effective if any taxi in any place could be redirected. Politic reasons make this idea an utopia[37].

[35] Business dictionary. "A person, group or organization that has interest or concern in an organization. Stakeholders can affect or be affected by the organization's actions, objectives and policies".

[36] This subsection has been elaborated with the help of professor Rafaél Pérez (IDETIC).

[37] Teldenoticias.

Buses

The model would give the same benefits than in the case of taxis but with a restriction. Buses have their own lines and fixed routes. The way in which buses could improve their benefits would be by increasing or decreasing bus frequency in a specific line depending on the clumps and traffic issues. As in the case of taxis, cameras in buses stops would indicate the most crowded bus stops, in real time, and would give the information required to modify the frequency. The difference with the situation before the model is that the changes in frequencies could be done in real time, not only in special events. This would suppose an important cost reduction due mainly to the reduction in energy consumption by fitting best the offer with the demand.

Secondly, information emerged from Big Dada Platform would also provide the bus company with information that it could use in order to optimize the bus network, knowing if some bus stops are normally empty, analyzing origins and destinies of passengers and describing most common routes for then optimize them and so on.

Citizens

This new model will allow the creation of new applications that will do nothing more than increase citizens' quality of life, making easier every daily task. The more organized data the more uses it would have. Specifically, M2M technology will suppose a great advantage for urban transport passengers due to the fact that this technology will advance their movements, and even thoughts, before they do them. This means that the service will be adapted to them. Waiting times would be reduced; routes would be more efficient and, for that reason, faster than now; the vehicle would not be so crowded but not so empty, in summary, the service would be much more adequate than nowadays.

Emergency services

We could include in this category ambulances and police. Thanks to M2M technology, these services would have the possibility to arrive earlier to the place of the accident or the emergency and even to know where the accident is due to the alarms sent by sensors. This is because they would have the appropriated technology, like GPS providing them with real data. Furthermore, M2M technology could also been applied to devices which control traffic, such as traffic lights, in order to allow the fastest route for these service when an incident happens. This is an interesting point and there is a lot of theory related to this topic but is not our purpose with the work, so we are not going to delve in this.

Private Companies

The impact of this new transport paradigm in LPA_GC will suppose a great market niche for different types of companies. Another Master Thesis could be done explaining in detail how companies could exploit traffic big data in order to improve their companies (this information would be sold to companies that ask for it by the Big Data platform). For example:

- **Marketing actions in the company**: business can increase (or decrease) its marketing actions if they control the most crowded (or the most empty) slots in some areas. Knowing the transit pattern in their area, or even real data which advise them of

the number of people that is expected to be in their area in the next hours, their marketing actions could be better organized. In addition, urban traffic data could help companies in order to know where they clients come from for increasing their marketing action in those places.

- **Direct Marketing actions**: knowing where people are concentrated in each moment is useful for companies that use direct marketing (individual sales reps in the street). They could focus their marketing efforts in specific zones with the security that lots of people are going to be in these zones.
  A direct marketing alternative is publicity in mobiles and any smart device. With M2M technology (Bluetooth connections) publicity and offers could be sent to people who are passing next to your business in real time. This could suppose a huge advantage for companies because the effort that clients have to do to go to the business if they are next to it are less than if they are far away and, obviously, this would be translated into more sales and profits.

- **New companies**: as the two cases above, being aware of the quantity of people in different slots and in different streets, knowing most common buses routes, most crowded bus stops and so on could help new companies to know where to put their office, shop or whatever. These new companies could pay for information even before their real presence in the area. Market studies will improve their quality thanks to this Big Data platform.

- **Marketing performance analysis**: information about if marketing actions are having or not effect on people could be analysed not only looking at the sales but looking at the urban traffic data. If when the company increases its marketing actions in somewhere and people modify their routes and habits despite sales, is that the company is doing well in marketing terms.

- **Logistics:** as well as for urban transport companies, other companies could organize better their logistics with the applications of the new model. For example, companies like *Correos* could increase the level of efficacy by buying information to the Big Data platform and applying to their current logistic system, improving it. This could happen also with transportation companies in general and with the logistic department of any company.

6. RISKS ASSOCIATED TO THE MODEL

Up to now some possible benefits have been analyzed with the model. However, different threats and possible damages that could emerge with it have to be taken into account.

A risk associated to a project is an uncertain event that, if it is materialized, it will have a positive or negative effect in the project[38].

Therefore, this layout will be followed:

1. Identify possible risks with negative effects that could affect the viability of the model.

2. Analyze type of risks, probabilities and possible impact on the model.

3. Contribute with recommendations to minimize threats that these risks could create.

Hereafter, the above layout is going to be followed with some risks that could happen if the model is implemented in the city. These risks are going to be classified according to Business Risks Structure (BRS)[39], which assures a complete process of risks identification with a high level of detail.

Organizational risks

A probable risk within this category would be the fact that information collected in the Big Data platform would not be valid. The reason of this is normally that information is not perfectly structured, due to the initial uncertainty of the information requirements.

The better thing would be include only required information, in this case: urban traffic information and traffic information in general captured from sensors. For avoiding including unnecessary information previous exhaustive analysis could be done. The manager of the Big Data platform should have a reunion with stakeholders in order to identify what the information needed is and where this information is before including it in the platform.

Financial Risks

In this category the greatest risk is the investment needed to run this model.

It would be necessary a huge amount of money to design, create and implement the Big Data. Data Base production, data collection from different sensors and data transformation would suppose an enormous effort and resources, not only from the managerial point of view, but from each part integrated in the model. This is because they need to adapt their current services and processes to this new way of exchanging information.

[38] Instituto Nacional de Tecnologías de la Comunicación (2008).

[39] Project Management Institute (2008), p. 259-260.

Big Data Platform managerial scenarios

Integrated and separated data, in other words, useful traffic data emerges from this platform and would be interesting for different stakeholders. The question is: who is going to control the platform? Trying to answer this question, three figures have been considered.

The institution in charge of the platform, the manager, would be the responsible of converting raw data in smart data, which is not an easy work. The technological basement needed is huge and also the investment. Others interested institutions in these data would only have to buy the specific data of their interest, which is an easiest but trickier job. This is because buying elaborated data does not assure the buyer that data is perfectly correct and without any failure. So, each position, being the manager or being a simple buyer, implies risks. Being aware of this, let's explain what figures could be in charge.

Scenario 1: Private Company

A great amount of private companies have noticed that Big Data, Internet of Things and everything related to the "smart trend" in general, is a huge market niche. No wonder that this managerial option is the most common one; 90% of data saved in the world have been generated during the last two years from different sources and companies want to obtain profit from this[40].

Private companies offer smart solutions to the City Council of a city and later this company will take the necessary actions and will be in charge of the project. For example, La Coruña relied on Indra Company S.A to be the leader company in charge of "Smart Coruña project"[41]. Indra Company offers a platform called Sofia2 which its successful performance has been demonstrated in lots of cases.

This option brings advantages and disadvantages to a city. The company, which normally is a technological company, has experience in smart terms and the success of the project is practically assured. Furthermore, the experience will permit that data quality would be probably higher than if a company without experience in data treatment would look after the whole process of collecting and processing data. This point is interesting because the prestige of the company will influence in the willingness to pay for information of the rest of stakeholders, which will be higher than if the company is not well known or has not got much experience.

Disadvantages are that this company will bring its own workers, which probably would not suppose job creation, and, in addition, the private company will control raw data and this is a risk for the city council because prices of the information would be fixed for this company. Additionally, data control will allow this private company for selling information to anyone of its interests, thing that could be dangerous for the City Council because of growing competition and lack of control.

[40] CincoDías.
[41] http://www.indracompany.com

Scenario 2: City Council

The city council, in our case LPA_GC City Council, could also be the manager. The difference from the private company is that it does not have the same experience and the same technological basement than the other. Workers would be probably less qualified in this particular area of work and, due to this reason; data treatment could be less qualified than in the case of private companies. It is clear that the risk of inaccurate data could be an immense problem because elaborated data would be sold to other stakeholders which pay for information of quality. In addition, the City Council should do a huge investment in creating the system that could make possible data treatment. In some manner, this is not bad. This is because the investment will benefit local people, creating jobs in the short and long term and, if everything goes right, profits will surpass investment in the medium term. More advantages are that the City Council would not lose the information control, it would be the centre of the information market and would obtain, obviously, free data to provide all the organizations under its command (for example Guaguas Municipales). The City Council could establish some kind of "taxes system", which could be used to provide stakeholders with information in return for this payment. Doing this, little and medium companies and, in general, anyone interested in data, would be also benefited from the lowest prices that the City Council would established in contrast to the private company.

Scenario 3: Joint venture: City Council & Private Company

"Joint venture is a legal organization that takes the form of a short term partnership in which the persons jointly undertake a transaction for mutual profit. Generally each person contributes assets and share risks. Like a partnership, joint ventures can involve any type of business transaction and the "persons" involved can be individuals, groups of individuals, companies, or corporations"[42].

From the analysis above of advantages and disadvantages of each managerial possibility emerges the idea of develop this new business in conjoint. Joint venture between the City Council and the Private Company appears to be the smartest option. An agreement between these two could work as the following.

The private company, with experience in this field would look after the beginning of the project, in which it brings its own experience workers and build the entire infrastructure needed. They will be in charge of the whole process while workers of the City Council would be learning how to run this Big Data platform with the security of obtaining data of quality. In an allotted time, the private company will "abandon" the project and it would be in charge of the city Council and their workers, now qualified. In the long term, local workers will be responsible of this project, which was one of the disadvantages of the private company management. Another solved disadvantage is that the risk of data lack of control would be solved because in the long term the owner of data will be the City Council because, as we have said, the Private Company will only be responsible of the project at the very beginning.

There is no need to say that the Private Company will obtain profits from this agreement. The payment method will be discussed between the two parts.

[42] Legal Information Institute .

Market Risks

Within this category two possible risks have been detected: model rejection from the part of urban transport companies (taxis and buses) and reluctance to contribute with internal data.

On the one hand, one of the advantages of the model could be decreasing the number of vehicles circulating at some slot (for example: in the case of buses, increasing or decreasing the frequency depending on the demand in each slot). This could generate refusal on the part of the buses company mainly because converting the service into more flexible would suppose that bus drivers would have more flexible work times. Maybe they have to drive one day many times more than other day. In addition, this model could suppose a reduction in human resources within the bus company, which would not be accepted from everyone.

On the other hand, as it was detailed before, the ideal performance of the model suppose that the information sources would be permanently contributing with real time information to the Big Data platform. Nevertheless, this issue could not satisfy the interests of the information sources because maybe, thanks to their internal information, competence will see their profits and their market satisfaction increasing.

To avoid aggressive competition and good faith, agreements could be signed between the interested parts in the model success. In those agreements they will compromise to do fair competition despite what data could offer them.

Technical risks

One of the most important a dangerous risk is found in this category and is information security in the Big Data platform.

Information security is one of the aspects with bigger importance for all stakeholders in the model, due to the fact that the greatest part of data in big data is confidential and sensible for each of them. In our specific case, the sensible and confidential data would come from taxis and buses and also personal information that sensors could capture.

Due to the evolution of hackers' world, if Big Data would not have an extreme protection, in not so much time it would suffer cyber attacks, which could end in modifications and thefts of data. For this reason is very important the security of the system.

To avoid this threat it would be necessary to reach the three basic principles in Big Data security terms: protect the confidentiality of data, preserve the integrity and promote the availability of it (CIA)[43].

Data base integrity is referred to the updating and accuracy of the information contained in it. One way to assure the integrity could be electronic signature in data uploading and, then, make sure that the signature matches with the authorised person, natural or legal, who is in charge of this uploading process. Doing this, the Big Data platform manager will assure that data is real.

[43] Mark S. Merkow, Jim Breithaupt (2014).

But confidentiality of data destiny could also be controlled by this signature process. In this case, anyone who wants to download information has to signee electronically. This will determine the accessibility degree of each stakeholder, in other words, who is allowed to obtain which information.

Availability principle would be, in some manner, the base of the model.Data have to be available in each moment. It would be a requirement that if any stakeholder wants to consult data these would be available. The tool which would assure data availability would consist in a second engine which we can call "reserve engine". This will mean that if the main engine fails, automatically the reserve engine starts to work, in which same data could be found.

Finally, confidentiality principle would be also important. All the information collected in this Big Data platform must fulfil requirements established in "Ley Orgánica de Protección de Datos de Carácter Personal"[44]. For this purpose, data could be encrypted, allowing only authorised agents to consult it.

Risks Impact Matrix of the model

Risks likelihood could be divided in three levels:

1. High: the likelihood of the risk is with great certainty high.

2. Medium: the likelihood of the risk depends on other factors.

3. Low: the likelihood of the risk is with great certainty low.

In the following table, called Risks Impact Matrix, the risks of the model which have been detected throughout this paragraph are summarized. Potential impact, likelihood of each risk, and possible recommendations to minimize the effect are included.

Table 10: Risks Impact Matrix

CATEGORY	RISK	LIKELIHOOD	POSSIBLE SOLUTION
Organizational	Bad structured information due to the initial unawareness of the information required.	Medium	Business meetings with each interested part in the model.

[44] Boletín Oficial del Estado (1999).

Financial	Resources failure for developing the Big Data Platform.	High	Analyse which of the three scenarios would be better depending on the financial situation of each agent. • Scenario 1 Private Company • Scenario 2 City Council • Scenario 3 Joint Venture
Financial	Resources failure for the infrastructure and sensors.	High	
Market	Model rejection from the part of information sources	High	___
Market	Information exchange refusal	Low	Good faith agreements of the information uses.
Technical	Information collected in the Big Data platform insecurity.	High	Fulfil the three Big Data principles CIA: • Confidentiality • Integrity • Availability

Source: own preparation.

7. CONCLUSION

In the current Masther Thesis a Smart Mobility model has been constructed in theoretical terms trying to accomplish all the requirements expected from any management model within the context of the Smart City; based on the use of IT, decreasing people movements and sensible to the environment. In addition, we have focused our model in Las Palmas de Gran Canaria city. However, the only thing that would change if the model wants to be applied in another city are the information sources, that in this specific case are taxis and buses (due to the urban transport system of the city), but them could be any other transport mode, depending on how the transport in the selected city is organized.

The aim of the work that was established at the beginning of it is fulfilled with the performance of the model: decreasing congestion while decreasing pollution. In addition, a large list of benefits different from these two is described as well.

On the one hand, sharing information with the Big Data base would allow better management possibilities for all stakeholders interested on it. Traffic could be organized in a more efficient way **minimizing the urban congestion problem**.

On the other hand, this model would suppose both savings for transport companies and **reduction in pollution**.

Nevertheless, risks which could be emerged from the performance of the model have to be taken into account. For example, investment needed to run the model and the possible rejection on the part of stakeholders.

Without any doubt, the greatest risk is information security in the Big Data platform. The likelihood of this risk is high because of the increasing number of hackers, people capable to extract sensible and confidential information from this platform. The potential effect on the model would be critical, due to the fact that without a secure data base the model would not be valid. For this reason, it would be necessary to define actions that ensure the address of the three basic principles in Big Data security terms: confidentiality, integrity and availability.

Recommendations

To conclude, as final recommendations, I would say that, in my opinion, after researching in this field I believe that urban congestion problem is a real and huge problem and actions to stop pollution caused by it have to be taken before it is too late. The interest in the model application is not only for environmental issues but for citizens' quality of live. A best organized city in traffic terms could permit a better life and, because of day by day more people are been concentrated in cities, this issue turns into a must.

Limitations

The reason why I added this clarification is because when my master tutor and I started to think in the current work we agreed in that the best idea was doing deep interviews to people in the City Council of Las Palmas de Gran Canaria. To our disappointment this could not be possible. After various attempts to get an appointment we finally gave up in this idea and the work carried on without these interviews. Additionally, it would not be possible to work with real traffic data so that is why the model proposed in this work is a theoretical one.

Furthermore, it could be said that model implementation could not be done immediately because of the IT base needed in Las Palmas de Gran Canaria. Therefore, it is possible that when the technological base is ready new IT exists, so, maybe this kind of proposal would be obsolete by the time.

Future research lines

Our work has been focused on passenger transport, due to the fact that a more complex model would require more time, deeper and complex investigation. However, lots of investigation lines emerged from this topic. We have found the idea of extends the benefits that this model could give to private companies, emergency services or others very interesting. Each private company is different from the other and that is why it could suppose a challenge in this work, but it is an interesting topic for a PhD or for any further investigation.

8. REFERENCES

Ayuntamiento de A Coruña (no date): "Coruña Smart City". (Date consulted: 16-Febreruary-2015).

Ayuntamiento de Las Palmas de Gran Canaria (no date; a): "LPA_GC Modelo de Ciudad Inteligente".

http://www.laspalmasgc.es/export/sites/laspalmasgc/.galleries/documentos-innovacion/lpa-gc_smartcity.pdf (Date consulted: 02-February-2015).

Ayuntamiento de Las Palmas de Gran Canaria (no date; b): "Movilidad en Transformación".

http://www.laspalmasgc.es/export/sites/laspalmasgc/.galleries/documentos-otras-secciones/LPA-GC-Movilidad.pdf. (Date conuslted: 02-February-2015).

Ayuntamiento de Las Palmas de Gran Canaria (no date; c): "LPA_GC Calidad de vida para todas las personas y familias 2014-2020".

http://www.laspalmasgc.es/export/sites/laspalmasgc/.galleries/documentos-otras-secciones/140317-Plan-LPA_GC-Calidad-de-Vida.pdf (Date consulted: 02-February-2015).

Ayuntamiento de Las Palmas de Gran Canaria (no date; d): "LPA_GC Destino Urbano".

http://www.laspalmasgc.es/export/sites/laspalmasgc/.galleries/documentos-otras-secciones/LPA-GC-Turismo.pdf (Date consulted: 12-February-2015).

Ayuntamiento de Santander (No date): "Santander Smart City; Plan Director de Innovación"

portal.ayto-santander.es/documentos/plan_director_innovacion.pdf (Date consulted: 05-May-2015).

Boletín Oficial del Estado, (1999): "Ley Orgánica de Protección de Datos de Carácter Personal".

http://www.boe.es/boe/dias/1999/12/14/pdfs/A43088-43099.pdf (Date consulted: 3-April-2015).

Carme Miralles-Guasch and Ángel Cebollada i Frontera (2003): "Movilidad y trasporte. Opciones políticas para la ciudad".

Centro Español de Logística; Organización Empresarial de Logística y Transporte (UNO) y Ayuntamiento de Colada (2014): "Gestión de la Seguridad en la Cadena de Suministro y las Infraestructuras Críticas". Madrid, Departamento de Comunicación Centro Español de Logística (Date consulted: 01-March-2015).

Colegio Oficial de Ingenieros de Telecomunicación & Asociación Española de Ingenieros de Telecomunicación (no date): "Behind Smart Cities Worldwide; Models, Projects, Innovations: Policies from the local to regional and supranational levels".

http://www.falternativas.org/content/download/5686/163153/file/fa70_15-11-06_doc25.pdf. (Date consulted: 03-April-2015).

Fernández, J.L.; Parapar, C. y Ruíz, M. (No date): "El envejecimiento de la población."

http://www.fgcsic.es/lychnos/es_es/artiuclos/envejecimiento_población (Date consulted: 20-January-2015).

Giffinger, R, et al (2007): "Smart cities - Ranking of European medium- sized cities". Centre of Regional Science, Vienna UT (Date consulted: 12-February-2015).

Gillis, J., (2014): "Desastre climático: la ONU advierte sobre la necesidad de tomar medidas urgentes".

http://archivo.losandes.com.ar/notas/2014/4/20/desastre-climatico-advierte-sobre-necesidad-tomar-medidas-urgentes-780417.asp (Date consulted: 02-June-2015).

G.I.S.T. Grupo de Investigación de Sistemas de Transporte Universidad de Cantabria. Universidad de Cantabria (2013): "Estudio de Seguimiento e Indicadores del plan de Movilidad Sostenible de Santander 2010-2013".

portal.ayto-santander.es/documentos/seguimiento_movilidad_2015.pdf (Date consulted: 05-May-2015).

Gobierno de España, Red.es, SEGITUR, E.O.I and IDAE (2015): "Plan Nacional de Ciudades Inteligentes"

http://webcache.googleusercontent.com/search?q=cache:EA-tyvcAdM8J:www.agendadigital.gob.es/planes-actuaciones/Paginas/plan-nacional-ciudades-inteligentes.aspx+&cd=1&hl=es&ct=clnk&gl=es (Date consulted: 09-March-2015).

INE (2011): "Censo de Población y viviendas 2011; ¿Cómo es España?; 25 mapas para descubrirla km^2 a km^2" (Date consulted: 18-May-2015).

INE (2014): "Notas de prensa. Proyección de población de España 2014-2064".

www.ine.es/prensa/np870.pdf (Date Consulted: 15-January-2015).

INDRA (2015): "Sofia 2: Smart IoT Platform"

http://sofia2.com/docs/SOFIA2-Plataforma_IoT(febrero_2015).pdf (Date consulted: 09-April-2015).

Instituto Nacional de Tecnologías de la Comunicación (2008): “Guía Avanzada de Gestión de Riesgos”.

www.inteco.es/file/teW3c753nhRRK6a0e7iZKg (Date consulted: 7-May-2015).

Juan Luis Domenech Quesada; Asociación Española de Normalización y Certificación (2007): " Huella ecológica y desarrollo sostenible". Spain.

http://www.aenor.es/aenor/descargadocumento.asp?nomfich=/Documentos/Comercial/Archivos/PUB_DOC_Tabla_AEN_6172_1.pdf&cd_publicacion=6172&cd_publicacion_doc=1 (Date consulted: 06-January-2015).

MARKESS International (2012): "la gestión intelligente avec le numérique: une nouvelle fynamique pour les villes et territoires francais."

http://blog.administrationnumerique.markess.com/2012/09/la-gestion-intelligente-avec-le-numerique-une-nouvelle-dynamique-pour-les-villes-et-territoires-francais/ (Date consulted: 26-February-2015).

Mark S. Merkow, Jim Breithaupt (2014): Information security: Principles and practices. Second edition. Pearson (Date consulted: 28-May-2015).

Masachusetts Institute of Techonology (2005): "Smart Mobility: Rethinking the Paris Bus Line. Smart Cities Group/MIT Media Lab. Spring 2005".

http://mobile.mit.edu/proj/smartmobility/ (Date consulted: 17-March-2015).

Miguel García (2015): EPSI: European Public Sector Information Platform; Topic Report No. 2015/04 "New businesses around open data, smart cities and wifare".

Pedret, V., (2011): “El nuevo libro blanco "Transporte 2050" de la Comisión Europea y la movilidad urbana” en Comisión Europea. Conferencia de Presentación de los Resultados Finales Proyecto E-Cosmos. Comisión Europea, 18 y 19 de octubre de 2011, Madrid.

http://www.ccoo.es/comunes/recursos/1/doc84130_Libro_Blanco_del_Transporte_y_la_Movilidad_Urbana.pdf (Date consulted: 13-April-2015).

Project Management Institute, Inc., (2008): "Guía de los Fundamentos para la Dirección de Proyectos" (Guía PMBOK). Third edition. Pennsylvania.

Professor Rafaél Pérez (IDETIC).

Real Academia de Ingeniería (2009): "La contribución de las TIC a la sostenibilidad del transporte en España".

http://www.raing.es/es/publicaciones/libros/la-contribuci-n-de-las-tic-la sostenibilidad-del-transporte-en-espa (Date consulted: 01-March-2015).

Subsecretaría de Transportes. Gobierno de Chile (2014): "Estrategia de Ciudad Inteligente para el Transporte; Chile 2020".

http://www.ciudadesinteligentes.gob.cl/wp-content/uploads/2014/09/COMPRIMIDO-estrategia_ciudad_inteligente.pdf (Date consulted: 25-March-2015).

Universitat Politécninca de Catalunya (No date): "Contribución al desarrollo de modelos y herramientas para la "Smart Mobility".

http://es.slideshare.net/inLabFIB/smart-mobility-en-smart-cities (Date consulted: 16-May-2015).

ELETRONIC RESOURCES

Autoridad única de Transporte Gran Canaria. http://www.autgc.net (Date consulted: 24-April-2015).

Business Dictionary. http://www.businessdictionary.com/definition/stakeholder.html#ixzz3bS2V6nML. (Date consulted: 19-April-2015).

Cinco Días. http://cincodias.com/cincodias/2014/08/14/tecnologia/1408040000_071970.html (Date consulted: 18-March-2015).

Data Science Central. http://www.datasciencecentral.com/forum/topics/the-3vs-that-define-big-data (Date consulted: 01-June-2015).

Ecologistas en acción. http://www.ecologistasenaccion.es/article9846.html (Date consulted: 26-May-2015).

El Mundo. "Las 'Smart Cities' mundiales miran hacia Barcelona".

http://www.elmundo.es/economia/2015/03/03/54f4c31aca4741f5268b456c.html (Date conusulted: 23-May-2015).

El País. http://esmateria.com/2013/05/02/investigadores-de-barcelona-crean-un-sistema-inteligente-de-gestion-del-trafico/ (Date consulted: 17-March-2015).

Global. http://www.globalsu.net (Date consulted: 24-April-2015).

Guaguas. http://www.guaguas.com (Date consulted: 24-April-2015).

IBM DeveloperWorld. https://www.ibm.com/developerworks/ssa/local/im/que-es-big-data/ (Date consulted: 01-June-2015).

Indra.http://www.indracompany.com/sostenibilidad-e-innovacion/proyectos-innovacion/coruna-smart-city-17725 (Date consulted: 15-May-2015).

Instituto de marketing online. http://www.educacionline.com/instituto-de-marketing-online/wp-content/uploads/big-data-infograph.jpg (Date consulted: 08-April-2015).

ISTAC (2014): http://www.gobiernodecanarias.org/istac/jaxi-istac/tabla.do (Date consulted: 09-April-2015).

Legal Information Institute. https://www.law.cornell.edu/wex/joint_venture (Date consulted: 02-June-2015).

RECI. www.redciudadesinteligentes.es/ (Date consulted: 05-January-2015).

Smart Cities. http://www.smart-cities.eu/ (Date consulted: 15-February-2015).

Taragranca. htpp://www.taragranca.org (Date consulted: 24-April-2015)

Teldenoticias.http://teldenoticias.com/index.php?tags=Telde%20Noticias%20Transporte&pag=view_new&nid=6796 (Date consulted: 01-June2015).

20 minutos. http://www.20minutos.es/noticia/2089892/0/domotica/hogar/internet/ (Date consulted: 15-march-2015).

Wikipedia(a) http://es.wikipedia.org/wiki/RFID (Date consulted: 09-May-2015).

Wikipedia(b). htttp://es.wikipedia.org/wiki/Circuito_cerrado_de_televisión (Date consulted: 06-May-2015).

Wikipedia(c). http://es.wikipedia.org/wiki/Sistema_de_posicionamiento_global (Date consulted: 06-May-2015).

Wikipedia(d). http://es.wikipedia.org/wiki/Extract,_transform_and_load (Date consuled: 10-May-2015).

Wikipedia(e): http://es.wikipedia.org/wiki/Las_Palmas_de_Gran_Canaria (Date consulted: 07-Febreuary-2015).