SMARTSANTANDER

SEVENTH FRAMEWORK PROGRAMME

SMARTSANTANDER PROJECT

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D4.1

Baseline report with Key Performance Indicators of selected city services

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Abstract: This document covers the scenarios and use cases that are planned to be developed and deployed in these initial phases of the project SmartSantander. The main purpose of this paper is to describe the use cases in the way they are currently developed in the city of Santander and its potential improvements through the IoT technology. Each scenario is accompanied by a set of key performance and economic indicators that will assist with their further evaluation.

Keyword list: Use case, Scenario, Key Performance Indicator, Economic Indicator, Assessment.

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Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

ECI	Economic Indicator
IoT	Internet of Things
KPI	Key Performance Indicator
MTO	Municipal Traffic Ordinance
RD	Real Decreto (Royal Decree)

Table 1 – Acronyms and Abbreviations

EXECUTIVE SUMMARY

The SmartSantander FP7 project is aiming at the deployment of a unique facility composed of Internet of Things (IoT) nodes in the city of Santander as well as in Belgrade, Guildford and Lübeck. The main objective of the project is the creation of an infrastructure, which allows experimentation on top of it whilst concurrently supporting service provision related to the different operational domains of the city.

In this context, WP4 encompasses the analysis, development and assessment of the use cases more closely linked to the citizens. Hence, this document is the natural evolution of the IR4.1, which gathered a plethora of services and applications with the potentiality to be supported in the city. Based on recommendations from the local authorities as well as on the citizens prioritization, a subset of those services were selected to be analyzed under the KPI framework. As a result, traffic control and environmental monitoring have emerged as the key applications deployed during the first phase. A description of both use cases is provided according to the present service provision. The role of the different stakeholder (local and regional authorities as well as technicians) is described. Afterwards, the potential improvements brought by the Internet of Things are postulated highlighting the pros and cons of using such technology. With an eye on the immediate future, both irrigation and augmented reality use cases are also described.

Traffic monitoring and environmental monitoring use cases are conveniently developed as part of Task 4.2. Last but not least, Task 4.3 will provide the corresponding assessment of the deployed services according to the citizen perspective.

1. INTRODUCTION

The smart city paradigm embraces many subjects both technological and sociological. Citizens play a major role in this paradigm as the final recipients of the services supported by the associated infrastructure. Furthermore, in order to meet tangible requirements it is important to involve them so as to consider their personal opinion when ranking different kinds of services.

In this framework, WP4 provides the service umbrella to the SmartSantander initiative by analyzing, designing and developing the services that are interpreted as a priority by the local authorities, regional government and users. In particular, this deliverable addresses the existing services in the Santander landscape prior to the introduction of the IoT technology and how these services can be improved by the deployment of the appropriate technology. In order to assess the deployment a set of performance indicators have to be identified. The purpose is to rely on objective qualitative and quantitative parameters that allow the operators to explicitly determine, for example, what amount of a specific pollutant emission is reduced or how the noise levels have been reduced due to the optimization of the traffic in the arteries of the city.

There is always the prospect for the selection of the use cases to be criticized, particularly when the expectations of the citizens are above the possibilities of the technology. Furthermore, it is not easy at all to conciliate the ways in which services are traditionally exploited with the introduction of a new technology. The companies exploiting such services perceive that they lose part of the service control whilst the local authorities gain knowledge on its performance. A nice example, experienced in Santander is related to the parking service in outdoor areas. Parking sensors have been deployed every 5 meters in those places in which lines are not painted. However, in many cases cars park in a quite anarchical way leaving not enough free space for another car to park, but enough to give a false free signal. However, when we contrast these cons with the pros (such as the projection of a city committed with the technology), there is no doubt that the latter has much more influence than the former.

In this framework, it is the objective of this deliverable to condense the plethora of services envisaged in the framework of a medium size city and to prioritize them according to several criteria. The main KPI's linked to those use cases are identified as well as the improvements that IoT technology might bring to such use cases.

2. SELECTED SCENARIOS AND SERVICES

2.1. Traffic Scenario

One of the most common use cases when invoking the smart city paradigm addresses integral traffic control. There are several components is such a use case. Among them, management of limited parking including specific spaces for people with disabilities, control of load and unload areas and traffic prediction are the most relevant elements to be considered.

In the following sections a description of these components is provided as well as the expected improvements potentially brought by the deployment of IoT technology in supporting the aforementioned use cases. Last but not least, the relevant KPI's are provided.

2.1.1. Limited Parking Management

- **Description and current service operation**

Presently, parking availability information given to users is basically linked to indoor parking lots. While many cities around the world (including Santander) provide outdoor parking areas, similar information is rarely available. The service of Limited Parking Management consists in the time regulation of the parking places in the centre of the city according to the Municipal Traffic Ordinance (MTO). A concessionaire company in charge of its maintenance, user payments management and surveillance of parking lots manages this service.

Concerning the part of the service that is expected to be modelled (surveillance of parking lots and user payments); we will describe its basic operation:

1. The surveillance of parking areas is made by a group of guards, required to patrol the different areas of the city, checking that all cars have a ticket on the dashboard in order to certify that the corresponding rates have been paid. This ticket data includes: timestamp; where the ticket was obtained; and how long the car is expected to be parked in that place. There is a time limit for parking in a given place so that once that time limit is reached, the car must be removed by its driver. The guards patrolling each area have to manually check every ticket, one by one. From the drivers' perspective, they have to locate an available parking space by driving along the streets in the hope of finding a space, without any kind of help.
2. Concerning payments, once the users have managed to park their car, they have to locate a fixed point where they can pay the corresponding price for parking and display the ticket as required. If a car does not display a valid ticket or the time limit is over, the guard will proceed to issue a penalty notice.

This service, in the way that has been explained, requires human resources in order to manually verify the validity of tickets. Meanwhile, the process of locating free places by users is tedious and sometimes fruitless, forcing them to drive for extended periods expending both fuel and time.

- **Expected improvements**

With the aim of reducing CO emissions and other pollutants, as well as petrol consumption, information and communication technologies (ICT) are becoming a transversal enabler. In this sense, IoT technology, characterized by its pervasiveness, is becoming a very attractive solution both technically and economically speaking. By deploying ferromagnetic wireless sensors buried under the asphalt, together the peer equipment in an area which guarantees communication with the sensors, as well as with the Internet, associated information is made available everywhere and all the time to the driver, traffic control responsible and local authorities.

In this context, the deployment of such an infrastructure and making the corresponding information available is expected to:

1. Make it easier for drivers to find available spaces in outdoor parking areas by informing them where and how many are available in a specific area and how to reach them (maximizing or minimizing some metrics).
2. Reduce CO emissions as well as petrol consumption.
3. Facilitate the exploitation of the parking service by allowing extracting occupancy models useful for further studies in terms of traffic prediction.

In Figure 1 an example is provided of how information is made available to drivers. This is complemented with applications running on mobile devices (Android, Windows mobile and Apple operating systems), phone calls and SMS to all types of mobile phones and e-mails to all mobile devices with internet access.

Further improvements could be made with the use of cameras to complement parking sensor information for whenever more detailed information or overall view of the parking area is requested. The use of IPTV cameras, complemented with applications running on fixed presentation devices (Smart panels) or on mobile devices, could provide real time information of parking area occupancy. This could be very helpful for citizens coming into the city enabling them to make on the fly decisions regarding what part of the city is better target to avoid wasting time and to reduce CO emissions and petrol consumption.

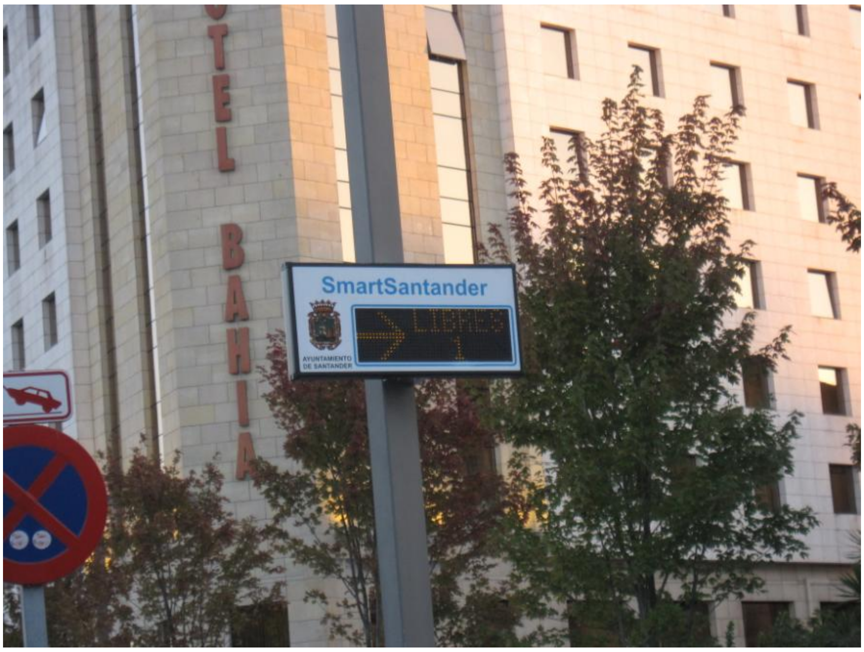

Figure 1: Information panel placed at the Cathedral area in Santander informing about free spaces

2.1.2. Load/Unload Areas Management

- **Description and current service operation**

Load/Unload areas play an important role for road traffic in cities. These areas are usually located in the city centre where relatively large vehicles have to make short stops to deliver or collect different goods.

The adequate management of these areas is essential for providing a fluent traffic, since the absence of free space usually forces carriers to stop their vehicles occupying part of the road.

Currently, this service is regulated by the municipal traffic ordinance that is enforced through the Local Police Department, which is responsible for monitoring of the traffic in the city. Generally, the control of loading/unloading areas is done through periodic visits to different places. This service is also provided upon request of the users who report the presence of unauthorized vehicles in the areas designated for loading and unloading of goods.

An authorized vehicle is understood to be any vehicle (especially trucks and vans) that needs to load or unload its goods in a certain area. However, an authorized vehicle could become in an unauthorized one as soon as it exceeds a certain amount of time without conducting any load/unload activity.

When an agent detects an unauthorized vehicle in a load/unload area, a penalty notice is issued and the vehicle is impounded (with a tow truck moving it to the vehicles depot).

We may distinguish two kinds of cost in this service. On the one hand, there are some costs related with the removal of unauthorised vehicles that will involve human resources like agents, operator for the tow truck as well as the material resources as vehicles, fuel, etc. On the other hand, we can find other costs associated with surveillance of the areas in order to keep them "clean and ready" for authorized vehicle use.

- **Expected improvements**

As mentioned in the previous section, these areas require a special effort by the local police, who are forced to periodically review compliance with the regulation applied, leading to the issue of tickets and even removal of vehicles with tow trucks.

The IoT technology is intended to ease the effort required for these control tasks through the different sensors and equipment to be deployed. The system delivers the following information regarding a concrete load/unload area:

  - State of designated areas: The installation of buried parking sensors allows detection of vehicle presence, providing awareness about the state of the areas as well as the cadence with which they get occupied. This information aids the authorities in decision making about the establishment of new load/unload areas.
  - Identification of users: The identification of the vehicles is not less important than the occupation. The system deployed permits the operators to discern if a user is authorized for load and unload tasks or on the contrary is using the restricted parking space for other purposes.

The services running on the current IoT platform are aimed at easing the typical tasks for the municipal traffic ordinance, enabling saving of time and effort; and ultimately the redistribution of these human resources elsewhere. Officers are informed via SMS, calls and e-mails when unauthorized users are occupying load/unload areas. Similarly, commercial drivers can receive real time information via phone calls and SMS to all types of mobile phones and e-mails to all mobile devices with internet access, thus enabling a more efficient performance, helping them to better schedule their deliveries. Citizens also benefit from these improvements, as the general traffic situation is less disturbed by daily load/unload operations.

In a similar manner to limited parking management, the use of IPTV cameras together with a suitable video recognition system could help in the detection of non-authorized vehicles in an automated way.

2.1.3. Parking Management for People with Disabilities

- **Description and current service operation**

The management and provision of easy access to urban facilities for disabled people is one of the main concerns for the governments in all modern cities around the world. The location of an available space for parking can be something very problematic for people with disabilities. A specific service by the local authorities is thus required to provide dedicated parking spaces that are available when required and comfortable enough to increase their quality of life.

This service is quite similar to the previous one and is also regulated by the MTO that is enforced through the Local Police Department.

In this case, the control of parking spaces for disabled people is reliant on citizens who, upon having detected the presence of an unauthorized vehicle, call the police for its removal. When an agent detects an unauthorized vehicle parked on an area reserved for disabled people, a penalty notice is issued and the vehicle is impounded.

As in the previous use case, this service can have two kinds of costs: costs associated with the removal of unauthorised vehicles and costs associated with surveillance of the parking areas. Here also, reduced costs and improved service can be achieved by automating the surveillance process enabling the redistribution of resources to address other tasks.

- **Expected improvements**

The overall improvement of the parking service is to enhance accessibility of people with disabilities in the city. It provides them the tools for reducing the effects of their handicap and enabling them to act more freely in the urban environment. In this specific case, the service allows people with disabilities to plan their trips to the city by giving them a complete overview of the current parking situation in the city via phone calls and SMS to all types of mobile phones and e-mails to all mobile devices with internet access. This allows them to enact more spontaneously. Users have also the possibility of pre-reserving a parking space. This provides them a "safety-hub" on their journey to the city, being more secure that they will have a parking space available for them.

From the City Council perspective, this service allows them to have an overview of the use of the parking lots in the city, giving them the means for future planning of the city parking areas for people with disabilities.

In case of unauthorised parking, the service triggers an alert to the authorities that will be able to send calls, SMS and e-mails to police officers in charge of that area, allowing them to react faster and more accurate in this situation. This functionality enhances the preventive effect of illegal parking in parking spaces for people with disabilities.

Finally, a number of additional location based services can be coupled to the parking service, for instance, an accessibility map of the buildings close to the parking lot.

2.1.4. Diagnosis and Prediction of Traffic

- **Description and current service operation**

The complete diagnosis and prediction of traffic is a major challenge in modern cities. Concretely, the municipality of Santander has deployed some infrastructure in order to monitor the fluency of traffic, especially during rush hours, adjusting the traffic lights cycles to facilitate access to main roads and highways. Nevertheless, the present facilities are inadequate. In some case, the diagnosis is made taking into account statistical reports provided by the police department. A real time monitoring of traffic would help the local authorities provide citizens with improved service through avoidance of traffic jams, location of free parking areas based on predictions about the volume of vehicles, etc.

- **Expected improvements**

As said before, IoT technologies are ubiquitous. This fact plays a key role when planning the traffic in a city. By identifying strategic probe points it is possible to derive models and mobility patterns for inbound, outbound and inner vehicle traffic. Figure 2 depicts potential points of presence for the wireless sensors measuring traffic.

The use of IPTV cameras together with a suitable video recognition system would also help in the definition of traffic models and mobility patterns in an automated way.

Once the traffic models and mobility patterns have been assessed they can be used to work on traffic prediction both in terms of estimating parking space occupancy/availability and route optimization for reaching a destination or alleviating potential congestion in conflictive areas.

Figure 2: Sensor localization in Santander for capturing 100% of the traffic flow

Hence, the deployment of IoT technology allows the operators to:

1. Assist the citizen driving in the city by supplying useful, concise and run time information via phone calls and SMS to all types of mobile phones and e-mails to all mobile devices with internet access.
2. Reduce traffic congestion providing at each moment the optimal route to different arteries in the city.

3. Contribute to the sustainability of the city in different axis, environmental, economical and quality of live.
4. Improve the perception of the city by the inhabitants and by the visitors.

2.1.5. List of Key Performance & Economic Indicators

KPI ID	**KPI.traffic.001**
Title	***Average time of site occupancy***
Description	This KPI measures the average time a site is occupied, in order to evaluate which parking areas are in greater demand by citizens to park and also the site's rotation. This measurement can help to balance the number of available parking sites within a certain parking area.
Measurement methodology	From the information provided by the system (the time a site is occupied), it will be possible to estimate the average time of occupancy
External factors	The value highly depends on the day and the hour (rush hour, weekend,…) that the measurement is taken.
Responsible for the KPI collection	City Council; Company in charge of controlling limited parking areas
External actors	–
Use cases affected	All cases related to the parking management

Table 2 - KPI.trafic.001 - Average of site occupancy

KPI ID	**KPI.traffic.002**
Title	***Average number of available parking sites***
Description	This KPI measures the average number of available parking sites, in order to know which parking areas are in greater demand by users.
Measurement methodology	From the information provided by the system regarding the number of available sites.
External factors	The value depends highly on the day and the hour (rush hour, weekend, …) that the measurement is taken.
Responsible for the KPI collection	City Council, Company in charge of controlling limited parking areas
External actors	–
Use cases affected	All cases related to the parking management

Table 3 - KPI.trafic.002 - Average number of available parking sites

KPI ID	**KPI.traffic.003**
Title	***Ratio between occupancy time and money collected***
Description	This KPI measures the relationship between occupancy time and money collected. If there is a great deviation between them, then the system is not reacting as quickly as hoped for the parking site management. Logically, the shorter the parking times the worse the system will react.
Measurement methodology	The KPI measurement can be calculated from the occupancy time data multiplied by the price per parking hour divided by the information about the money collected.
External factors	Number of people employed by the company in charge of controlling limited parking areas.
Responsible for the KPI collection	City Council, Company in charge of controlling limited parking areas
External actors	Citizens (drivers)
Use cases affected	Limited parking management

Table 4 - KPI.trafic.003 - Ratio between occupancy time and money collected

KPI ID	**KPI.traffic.004**
Title	***Use of parking spaces***
Description	The KPI measures the use of parking spaces for citizens. Use is defined as at least 1 minute occupancy of the parking space by a vehicle. Use can be authorized or unauthorized. The technology solution would be expected to result in a decrease in unauthorized use and ideally an increase in authorized use.
Measurement methodology	Current state of measurement is most likely based on incomplete data from surveys (authorized use) and police reports (unauthorized use). Once a basic system is put in place to count the number of users based on SmartSantander technology, the measurement method can be further revised.
External factors	-
Responsible for the KPI collection	City Council
External actors	Citizens (drivers)
Use cases affected	All cases related to the parking management.

Table 5 - KPI.traficc.004 - Use of parking spaces

KPI ID	**KPI.traffic.005**
Title	***Time required to find a parking place***
Description	The KPI measures the user experience of time taken for a person to find a parking space.
Measurement methodology	Current state of measurement is most likely based on interviews with users. Once a system is put in place to count the number of users based on SmartSantander technology the measurement method can be revised significantly.
External factors	City of Santander; Alexandra (current state of measurement – Aarhus data)
Responsible for the KPI collection	Users
External actors	–
Use cases affected	All cases related to the parking management. It could be useful to derive GHG emissions (Environmental Monitoring).

Table 6 - KPI.traficc.005 - Time required to find a parking space

KPI ID	**KPI.traffic.006**
Title	***Accessibility experience of user***
Description	The KPI measures the user experience of accessibility of parking spaces in a qualitative manner.
Measurement methodology	Measurement is based on interviews with users.
External factors	–
Responsible for the KPI collection	City Council
External actors	Various associations for persons with disabilities, users
Use cases affected	All cases related to the parking management (esp. disabled people parking places)

Table 7 - KPI.traficc.006 - Accessibility experience of user

KPI ID	**KPI.traffic.007**
Title	***Autonomy experience of user***
Description	The KPI measures the user experience of autonomy in finding parking spaces in a qualitative manner, e.g. spontaneous decisions, confidence about use, etc.
Measurement methodology	Measurement is based on interviews with users.
External factors	
Responsible for the KPI collection	City of Santander; Alexandra (Aarhus data).
External actors	Various associations for persons with disabilities, users.
Use cases affected	Parking for disabled people use case.

Table 8 - KPI.traffic.007 - Autonomy experience of user

KPI ID	**KPI.traffic.008**
Title	***Analysis of occupancy rate in parking areas***
Description	The KPI measures the occupancy rate in parking areas, in order to evaluate if more parking places are required in certain areas.
Measurement methodology	From SmartSantander experimental facility, it is possible to establish the occupied time in parking areas and calculate occupancy rate.
External factors	_
Responsible for the KPI collection	Service provider , City Council
External actors	Citizens (drivers)
Use cases affected	All cases related to the parking management

Table 9 - KPI.trafic.008 - Analysis of occupancy rate in parking areas

KPI ID	**KPI.traffic.009**
Title	***Analysis of average time of occupancy in parking areas***
Description	The KPI measures the average time of occupancy in parking areas, in order to evaluate the activity in certain areas.
Measurement methodology	Utilising the SmartSantander experimental facility, it is possible to calculate the average time of occupancy in load/unload areas through information from the sensor node network.
External factors	_
Responsible for the KPI collection	Service provider , City Council
External actors	Citizens (drivers)
Use cases affected	All cases related to the parking management

Table 10 - KPI.trafic.009 - Analysis of average time of occupancy in parking areas

KPI ID	**KPI.traffic.010**
Title	***Use of parking areas by unauthorized vehicles***
Description	The KPI measures the use of load/unload areas by unauthorized vehicles, when the usage duration exceeds 20 minutes for example.
Measurement methodology	From SmartSantander experimental facility, it is possible to calculate the number of unauthorized vehicles that occupy parking areas for more than 20 minutes for example.
External factors	_
Responsible for the KPI collection	Service provider , City Council
External actors	Citizens (drivers)
Use cases affected	All cases related to the parking management

Table 11 - KPI.trafic.010 - Use of parking areas by unauthorized vehicles

KPI ID	**KPI.traffic.011**
Title	***Protracted use of parking areas by authorized vehicles***
Description	The KPI measures the protracted use of parking areas for authorized vehicles, for example 1 hour or more.
Measurement methodology	From SmartSantander experimental facility, it is possible to calculate the number of authorized vehicles which occupy parking areas for more than 1 hour for example.
External factors	_
Responsible for the KPI collection	Service provider , City Council
External actors	Citizens (drivers)
Use cases affected	All cases related to the parking management

Table 12 - KPI.trafic.011 - Protracted use of parking areas by authorized vehicles

ECI ID	**ECI.traffic.001**
Title	***Cost of maintenance of service***
Description	The purpose of this indicator is to compare the overall cost of maintenance of the service before and after the deployment of the IoT devices.
Measurement methodology	In order to be precise, a full account of expenses for maintenance of facilities should be considered. Among these expenses, we could include at least personnel and material costs.
External factors	-
Responsible for the ECI collection	City Council (previous city facilities and human resources), SmartSantander Consortium (IoT facilities)
External actors	Maintenance companies
ECI reuse	This indicator is applicable to all cases which require maintenance of service.

Table 13 - ECI.trafic.001 - Cost of maintenance of service

2.2. Environment Scenario

2.2.1. Environmental monitoring

Due to global warming, governments around the world are devoting significant effort and resources to the management of the environment. The city of Santander, likewise, is also involved in this activity and is trying to carry out an effective policy for environmental management through the signing of agreements that aid improvements in air quality and quality of life for its citizens.

Key elements in undertaking this task are:

- Monitoring of pollutants
- Noise and temperature measurement

- **Description and current service operation**

  Santander has two monitoring stations for air quality included within Network Control and Monitoring of Air Quality of the Regional Government, which aims to control the state of the air, checking at all times its quality according to the measurement of a wide range of parameters.

  The potential pollutants or substances to be monitored in order to quantify the air quality are:

  - Particulates in suspension smaller than 10 micrometers (PM10) (RD 1073/2002)
  - Sulphur dioxide (SO_2) (RD 1073/2002)
  - Hydrogen sulphide (H_2S) (RD 833/1975)
  - Oxides of nitrogen (NO_x) (RD 1073/2002)
  - Carbon monoxide (CO) (RD 1073/2002)
  - Ozone (O_3) (RD 1796/2003)
  - Benzene, Toluene and Xylene (BTX) (RD 1073/2002)

  The above list includes the Spanish law which describes the correct way to monitor each pollutant in order to get a valid index of quality of air. Besides, each regulation also describes the exact location and nature of sensors to be used.

  It is important to note that the measurement of some of these substances/parameters in only two places in the city does not allow for a more detailed study of each of the areas of the city with potential pollution problems (particularly those due to traffic). The correlation of traffic data with other environmental parameters could indicate potential effects of greenhouse gases on the city and its citizens.

Another important parameter related with Environment is noise (RD 1513/2005). Currently, noise measurements are made through the Engineering Department in the Council in a timely manner; generally, in response to complaints, abnormal operation of some service, licensing applications, etc. However, it is an important issue for all cities to provide a real time map of noises which allows monitoring of the city providing periodic reports.

Finally, another interesting parameter from an environmental perspective is temperature monitoring at different points across the city. Its study could provide measurements useful for research the interaction of the traffic and pollutants with the environment and global warming.

- **Expected improvements**

Current solutions for environment monitoring in urban settings are based on a handful of measurement stations at fixed locations with the support of a large mobile measurement unit (used mainly used in case of certain emergency events). The accuracy of the measurement equipment in these units is high as is the cost of each unit, which makes it impossible to scale the solution and make measurements with finer granularity feasible.

With the introduction of the IoT technology, it is now possible to deploy a large number of low cost sensors for a fraction of cost of the current technology. The accuracy of these sensors is not as high as those used in the modern environment measurement stations. However, using a large number of measurement points and intelligent processing of the measurements, it is possible to obtain sufficiently accurate measurements that can be used as initial indicators of the status of environment pollution.

Deployment of low cost sensors can be done by attaching them to lampposts or buildings around the city. However, to achieve maximum efficiency in terms of coverage and the number of sensors, it is proposed to utilize public transport vehicles, taxis, vehicles belonging to emergency services and even police cars as the mobile measurement units. By deploying a set of relevant sensors on these vehicles and then taking measurements and tagging them with location as the vehicle is passing through a city, it is possible to cover large areas and obtain environmental pollution maps with high granularity.

The public transport vehicles will provide coverage of a large, but fixed area (usually the larger streets). Measurement equipment on the taxis and other public service vehicles will extend coverage to the additional areas, i.e. smaller streets not served by public transport. Consequently, the combination of these approaches will enable generation of environment pollution maps with much finer granularity than the current solutions. The accuracy of the individual sensors will be improved by appropriate algorithms for data reasoning and correlation.

2.2.2. Luminosity Measurement

- **<u>Description and current service operation</u>**

As with all facilities, the passage of time leads to a progressive decrease in the quality of service until its replacement by the end of its useful life. This period, as in the case of public lightning facilities, may range around 20 years. During this time, all actions are aimed at maintaining, as far as possible, the performance of the service. The standardized procedures for this goal are the following:

<u>Hiring a maintenance company</u>: This condition is not required, although depending on the nature and provisions of the relevant body, such a situation might be necessary

<u>Maintenance program</u>: This varies according to the needs, size and frequency of operations. In the case of Santander, this program is extensive, covering the specific aspects that are summarized below:

- Maintenance and repair of command centers, electric network, ground network, lampposts, bulbs, etc.
- The implementation of checks and verifications, quantitative and qualitative, of lighting and electronic components, lighting levels, consumption and measurements of insulation of conductors
- Resetting of lamps
- Repairing of all failures in the network
- Inspection, monitoring and verification of the facilities and its shortcomings

Modern technology offers solutions that are tested in the field of lighting, encompassing communication between the network and command center where all the electrical parameters of the facility are received. Combining these parameters provide both the control of energy of the facilities as well as the decision-making information for repairing electrical components, which means, in general, a greater efficiency of resources for their intended purposes.

However, there are areas that could provide an extra improvement over the aforementioned electrical parameters, such as:

<u>Continuous measurement of the light or luminance</u>: The decline of these values is closely linked to the life of the lamp and factors of maintenance and cleaning.

In the first case, no action is possible at all, while in the second case, a large reduction in light levels compared to the baseline could activate a trigger mechanism of the maintenance operating procedures aforementioned.

Currently, luminance measurements are performed by a vehicle driving through the city taking measurements at different points. This is done in periodic campaigns throughout the year but in spite of achieving its objective, does not provide the desired degree of accuracy.

- **Expected improvements**

Using luminosity sensors spread around the whole city will provide a more accurate knowledge of the current situation of the luminosity service. With the information sent by these sensors, several improvements can be achieved:

  - Any lamp could be switched on/off depending on luminosity conditions. The lamp only switches on when is needed and a saving cost in money and energy will be achieved.
  - With the information sent by these sensors a failed lamp can be detected, generating an alarm and an automatic replacement order from the command centre.
  - An on-line luminosity map could be created with the information generated by the sensors making the periodic vehicle campaign redundant. Using this map, the command center can monitor the state of the service at any time.
  - If the lamp has some command features, the information from the sensors can be used to take some active action from the command center or the lamp itself.

2.2.3. List of Key Performance & Economic Indicators

KPI ID	**KPI.env.001**
Title	***Average value of a measured parameter***
Description	This KPI provides the average value of a measured parameter.
Measurement methodology	This KPI should be calculated for each measured parameter. The time period for which this average is calculated shall be configurable, as well as the area where measurements are taken. All measurements shall be stored in a database, so information that is necessary for calculating this KPI can be fetched from there.
External factors	Meteorological aspects (rain, temperature, etc.), traffic
Responsible for the KPI collection	City Council, Regional Government
External actors	–
Use cases affected	Environmental monitoring, Luminosity Measurement, Traffic Scenario Use Cases

Table 14 - KPI.env.001 - Average value of a measured parameter

KPI ID	**KPI.env.002**
Title	***Increase/Decrease Rate of Value of Measured Parameter***
Description	This KPI provides the rate at which the value of measured parameter increases or decreases. When calculated in the short-term it can provide an early warning – before a threshold is reached and alarms raised. In the long-term it can provide trend information (e.g. increase in level of CO_2 in an area over a couple of years). This KPI should be calculated for all measured parameters.
Measurement methodology	All measurements shall be stored in a database, so information that is necessary for calculating this KPI can be fetched from there. KPI shall be derived by calculating the first derivative of the measurement data.
External factors	Meteorological aspects (rain, temperature, etc.), traffic
Responsible for the KPI collection	City Council, Regional Government
External actors	_
Use cases affected	Environmental monitoring, Luminosity Measurement, Traffic Scenario Use Cases

Table 15 - KPI.env.002 - Increase/Decrease Rate of a measured parameter

KPI ID	**KPI.env.003**
Title	***Number of Times an Alarm Has Been Raised***
Description	This KPI gives the number of times each of the parameters have reached a pre-defined threshold at which time an alarm had to be generated.
Measurement methodology	This number shall be counted at given time intervals, configured for specified areas. All alarms shall be stored in a database, so information that is necessary for calculating this KPI can be fetched from there.
External factors	Meteorological aspects (rain, temperature, etc.), traffic
Responsible for the KPI collection	City Council, Regional Government
External actors	-
Use cases affected	Environmental monitoring, Luminosity Measurement

Table 16 - KPI.env.003 - Number of Times an Alarm Has Been Raised

ECI ID	**ECI.env.001**
Title	***Cost of maintenance of facilities***
Description	The purpose of this indicator is to compare the overall cost of maintenance of the facilities before and after the deployment of the IoT devices.
Measurement methodology	In order to be precise, a full account of expenses for maintenance of facilities should be considered. Among these expenses, personnel and material costs could be included.
External factors	_
Responsible for the ECI collection	City Council (previous city facilities and human resources), SmartSantander Consortium (IoT facilities)
External actors	Maintenance companies
ECI reuse	This indicator is applicable to all cases which require maintenance of facilities.

Table 17 - ECI.env.001 - Cost of maintenance of facilities

ECI ID	**ECI.env.002**
Title	***Cost of energy consumption***
Description	The purpose of this indicator is to compare the electric energy consumption of devices before and after the deployment of the IoT devices. This consumption will not only include the IoT devices, but all the devices involved in the use case.
Measurement methodology	It will consist primarily in the comparison of costs of consumption before and after the use of IOT technologies.
External factors	_
Responsible for the ECI collection	City Council
External actors	Maintenance companies
ECI reuse	This indicator is applicable to all cases with electric elements involved in the proper functioning of the use case. Especially in the case of luminosity measurement.

Table 18 - ECI.env.002 - Cost of energy consumption

2.3. Parks and Gardens Scenario

Precision Plant Growing (or Precision Agriculture) is synonymous with innovative agricultural techniques to improve production or plant state and reduce environmental pollution. The benefits which arise from the application of precision agriculture techniques come from the precision in the irrigation quantity. Precision irrigation provides a means for evaluating a plant's water requirements and a means for applying the right amount at the right time. Precision irrigation focuses on individual plants or small areas within a park, while the traditional definition takes a 'whole-field' approach.

The development of WSN applications in precision irrigation and park monitoring makes it possible to increase efficiencies, productivity and profitability while minimizing unintended impacts on people's lives and the environment. The real time information from the fields will provide a solid base for park technicians to adjust strategies at any time. Instead of taking decisions based on some hypothetical average condition, which may not exist anywhere in reality, a precision park farming approach recognizes differences and adjusts management actions accordingly.

2.3.1. Precision Irrigation

- **Description and current service operation**

  The city of Santander has 61 parks with over 200 different tree species and countless plants and flowers. The maintenance of such a service is complex due to the heterogeneity of species that require different care and needs.

  Due to its privileged location in the north of Spain, the city of Santander has no problems with drought. However, it is important that each park and garden are watered when moisture circumstances are appropriate, in order to keep the proper preservation and growth of plants. Generally, current irrigation systems of the city parks are activated either manually by the technicians in charge of the service, or through automated timers that activate the systems regardless of soil moisture conditions.

- **Expected improvements**

  Using IoT infrastructures for parks and garden monitoring, as well as for precision irrigation, has substantial impact on resource utilization (in materials and labor) of municipality authorities [Smith 2009, Marks 2010]. Usually, a large number of points must cover all the greenery area of the city. These measurement points will be effectively distributed over the greenery area, given that different areas of the greenery will have different water requirements.

  Expected improvements (being aligned with European comprehensive rural development policy) are:

  - Improving irrigation infrastructure, as well as improving and maintaining water quality
  - Minimizing the environmental impact generated by irrigation, by minimizing dumping of water polluted by fertilizers [Cooley 2009]

- Minimizing the water waste, using the exact amounts of water needed for irrigation
- Minimizing the energy wasted for irrigation (eg. movement of the water supply vehicle, or movement of the gardeners in the extent of the city) [USC 2009]
- Promotion and dissemination of environmentally friendly growing techniques, especially techniques for the optimization of resources needed (water, energy, etc.). Precise irrigation will improve the efficiency, performance and ease of operation of irrigation scheduling. This has a major impact in terms of cost savings (labor and water costs), improved product quality and yield, and in the protection of biodiversity by maintaining water quality and flows rates in surface and ground waters.

2.3.2. List of Key Performance & Economic Indicators

KPI ID	**KPI.garden.001**
Title	***Average Value of Measured Parameter***
Description	This KPI provides average value of measured parameter. It should be calculated for each measured parameter. The following parameters are measured and average value calculated for: ▪ Luminosity ▪ Measurement of air humidity and temperature ▪ Rainfall ▪ Air wind measurements ▪ Soil moisture (30cm & 60cm depth) ▪ Leaf wetness ▪ soil temperature ▪ atmospheric pressure ▪ solar radiation ▪ wind speed/direction
Measurement methodology	The time period for which this average is calculated shall be configurable, as well area where measurements are taken. All measurements shall be stored in a database, so information that is necessary for calculating this KPI can be fetched from there.
External factors	Meteorological conditions
Responsible for the KPI collection	City Council, Park and Gardens maintenance company
External actors	–
Use cases affected	Environmental monitoring use cases. Even some interaction could be detected with traffic scenario cases.

Table 19 - KPI.garden.001 - Average value of measured parameter

KPI ID	KPI.garden.002
Title	*Variation rate of value of a measured parameter*
Description	This KPI provides the rate at which the value of measured parameter increases or decreases. When calculated in short-term it can provide an early warning – before threshold is reached and alarms raised. In long-term it can provide trend information (e.g. increase in level of CO2 in an area over a couple of years). This KPI should be calculated for all measured parameters.
Measurement methodology	All measurements shall be stored in a database, so information that is necessary for calculating this KPI can be fetched from there. The KPI shall be derived by calculating the first derivative of the measurement data.
External factors	Meteorological conditions
Responsible for the KPI collection	City Council, Park and Gardens maintenance company
External actors	–
Use cases affected	Environmental monitoring cases.

Table 20 - KPI.garden.002 - Variation rate of value of a measured parameter

KPI ID	KPI.garden.003
Title	*Number of times an alarm has been raised*
Description	This KPI gives the number of times each of the parameters have reached a pre-defined threshold when an alarm had to be generated.
Measurement methodology	This number shall be counted at given time intervals that can be configured and for specified area. All alarms shall be stored in a database, so information that is necessary for calculating this KPI can be fetched from there.
External factors	Meteorological conditions
Responsible for the KPI collection	City Council, Park and Gardens maintenance company
External actors	–
Use cases affected	–

Table 21 - KPI.garden.003 - Number of times an alarm has been raised

KPI ID	**KPI.garden.004**
Title	***Volume of utilized water***
Description	This KPI gives the volume of water utilized for irrigation purposes.
Measurement methodology	This number shall be counted at given time intervals that can be configured and for specified area. This quantity shall be stored in a database, so information that is necessary for calculating this KPI can be fetched from there.
External factors	Meteorological conditions
Responsible for the KPI collection	City Council, Park and Gardens maintenance company
External actors	-
Use cases affected	-

Table 22 - KPI.garden.004 - Volume of utilized water

KPI ID	**KPI.garden.005**
Title	***Volume of wasted water***
Description	This KPI gives the volume of water portion of the overall utilized for irrigation purposes that is not actually absorbed by the garden. This KPI can be estimated by measuring local water retention in the soil, and evapotranspiration.
Measurement methodology	This number shall be counted at given time intervals that can be configured and for specified area. This quantity shall be stored in a database, so information that is necessary for calculating this KPI can be fetched from there.
External factors	Meteorological conditions
Responsible for the KPI collection	City Council, Park and Gardens maintenance company
External actors	
Use cases affected	

Table 23 - KPI.garden.005 - Volume of wasted water

ECI ID	**ECI.garden.001**
Title	***Cost of maintenance of service***
Description	The purpose of this indicator is to compare the overall cost of maintenance of the service before and after the deployment of the IoT devices.
Measurement methodology	In order to be precise, a full account of expenses for maintenance of facilities should be considered. Among these expenses, we could include at least personnel and material costs.
External factors	
Responsible for the ECI collection	City Council, Park and Gardens maintenance company
External actors	Maintenance company
ECI reuse	This indicator is applicable to all cases that require maintenance of service.

Table 24 - ECI.garden.001 - Cost of maintenance of service

ECI ID	**ECI.garden.002**
Title	***Cost of water consumption***
Description	The purpose of this indicator is to compare the water consumption before and after the deployment of the IoT devices.
Measurement methodology	It will consist primarily in the comparison of costs of consumption before and after the use of IOT technologies.
External factors	Meteorological conditions (rain)
Responsible for the ECI collection	City Council, Park and Gardens maintenance company
External actors	Maintenance company
ECI reuse	This indicator is applicable to all cases which require water consumption.

Table 25 - ECI.garden.002 - Cost of water consumption

2.4. Tourist and Cultural Scenario

Augmented reality adds a digital layer to the real world situations and bridges the gap between the physical world and the internet. This allows service providers to use the digital layer to offer context specific services that can be easily consumed by the customers/citizens when being at this specific location. In this project we will consider the use of RFID tags in an augmented reality setting. By placing tags in specific points of interest in the city, we will provide citizens with an extra layer of information and will open the field for developing more complex services/functionalities.

2.4.1. Information through Augmented Reality

- **Description and current service operation**

  The city of Santander is a significant touristic destination in Spain. Besides its beaches, landscapes and other leisure activities, the city offers an important sample of monuments, activities related to culture, sea sports or congress throughout the year. In that sense, it is very important for local authorities to provide as much information as possible to visitors.

  Nowadays, the information dissemination related with the above-mentioned activities constitutes a big investment for the city in terms of human and material resources. Usually, it has been tackled by traditional means where tourism officers provide information about the city and its activities either directly through tourist offices located at different points in the city or, more recently, using new technologies such as web pages.

- **Expected improvements**

  This service provides the possibility of “tagging” points of interest in the city, for instance a touristic point of interest, shops and public places such as parks, squares, etc. In a small scale, the service provides an opportunity to distribute information in the urban environment as location based information. In a larger scale, the tags can be coupled with more advanced services such as “feedback” from the citizens to the city council.

  The service supports the tourists’ experience of the “stroll in the city.” For instance, along the way, the tourist will get direct access to information on a specific monument in the preferred language. This, in general, enhances the serendipity effect of the tourist visit.

  Furthermore, placing tags on certain shops in the city provides new opportunities for shops to build or strengthen customer relationships. The shops can explore the relationship between physical presence and the web. The users can get specific information about the shop, for instance, opening hours, contact, special offers, accessibility in the shop, etc.

  From the City Council perspective, the placement of tags in strategic places in urban facilities will provide location based information to the citizens. Additionally, more advanced services can allow citizens to report problems to the relevant authorities. For instance: “this traffic light is not working properly”, “the elevator is out of order”, “the stairs in the park are broken”, etc.

Besides, the tourists can subscribe services allowing them to receive specific information on touristic and cultural events via phone calls, SMS and e-mails.

Video streaming capabilities added to this service would further improve the user experience in getting access to Tourist and Cultural content on the City Council offerings and activities taking place in the town. Pre-recorded videos or real time videos (depending on the application and on legal issues) could be streamed to fixed presentation devices (Smart panel tags) or to subscribed mobile devices. The availability of such services on mobile devices could trigger a demand increase for these tourist and cultural events.

2.4.2. List of Key Performance & Economic Indicators

KPI ID	**KPI.tourism.001**
Title	***Number of times a specific tag was read***
Description	This KPI indicates the interest of the citizens in a specific point of interest, allowing the city council to have an overview of the interest of the tourists on a city attraction.
Measurement methodology	Counter increasing when a link is read.
External factors	_
Responsible for the KPI collection	City Council (Tourist department)
External actors	_
KPI reuse	_

Table 26 - KPI.tourism.001 - Number of times a specific tag was read

KPI ID	**KPI.tourism.002**
Title	***Enhancement of the user experience of the tourist attraction***
Description	This KPI measures in a qualitative way the enhancement of the experience by the user when in contact with a specific place.
Measurement methodology	Interviews with users
External factors	_
Responsible for the KPI collection	City Council (Tourist department)
External actors	Local stakeholders in experience industry
KPI reuse	_

Table 27 - KPI.tourism.002 - Enhancement of the user experience of tourist attraction

KPI ID	**KPI.tourism.003**
Title	***Number of accesses to the SmartSantander video servers***
Description	The KPI measures how many times users request the different videos stored in the video servers.
Measurement methodology	A simple counter must be in charge of counting the number of times one video server is accessed from different IP addresses.
External factors	_
Responsible for the KPI collection	City Council (Tourist department)
External actors	_
KPI reuse	_

Table 28 - KPI.tourism.003 - Number of accesses to the SmartSantander video servers

KPI ID	**KPI.tourism.004**
Title	***Average connection time to the video server***
Description	The KPI measures the average time the user is connected to the server, watching the selected video.
Measurement methodology	Averaging connection time of the different IP addresses to the video server.
External factors	Cut in the connection of the user to the internet
Responsible for the KPI collection	City Council (Tourist department)
External actors	_
KPI reuse	_

Table 29 - KPI.tourism.004 - Average connection time to the video server

ECI ID	**ECI.tourist.001**
Title	***Cost of maintenance of service***
Description	The purpose of this indicator is to compare the overall cost of maintenance of the service before and after the deployment of the IoT devices.
Measurement methodology	In order to be precise, a full account of expenses for maintenance of facilities should be considered. Among these expenses, we could include at least personnel and material costs.
External factors	_
Responsible for the ECI collection	City Council
External actors	_
ECI reuse	This indicator is applicable to all cases that require maintenance of service.

Table 30 - ECI.tourism.001 - Cost of maintenance of service

ECI ID	ECI.tourism.002
Title	*Increase of customer relationships through digital marketing*
Description	This ECI measures the increase of awareness of the shop and enhancement of sales.
Measurement methodology	Interviews with users and shop owners
External factors	_
Responsible for the ECI collection	City Council, Commercial associations.
External actors	Customers
ECI reuse	_

Table 31 - ECI.tourism.002 - Increase of customer relationships through digital marketing

3. CONCLUSIONS

As it has been stated, SmartSantander has a unique and singular profile due to its duality, that is, concurrently supporting both experimentation (open to the research and development community), and service provision. While significant effort is focused in the experimentation plane, the fact that the deployment is taking place in the city it allows to an extent the infrastructure to be utilised for supporting end-user services. This is precisely the main objective of WP4 Task 4.1, to make a thorough analysis of the use cases in the framework of the smart city, studying the real needs of the City and its citizens.

In undertaking such an analysis, the first issue tackled by the involved partners was to rank the services according to: citizen criteria; local and regional authorities; together with infrastructure and budget constraints. According to the analysis, it was derived that holistic traffic management and environmental monitoring (including both noise and luminosity intensity) were a priority. In this sense, a description of how the service is supported for the time being and which are the potential improvements derived from the IoT technology is included. Furthermore, several KPI's have been identified and they will serve as a basis in a medium/long term analysis for assessing the improvement brought by IoT technology when deployed for supporting the smart city concept.

Looking ahead to the second phase, two a priori attractive use cases have been presented. The first one is related with park and gardens management and the second with augmented reality. For the former, local authorities have shown interest in monitoring and controlling irrigation in an efficient way, which is an important issue in a city like Santander with over 60 gardens. For the latter, enhancing the information provided to tourists by deploying RFID devices in different areas of the city, has been postulated as a very interesting scenario. That information will provide users with data about public services, monuments and other activities in the city. From the experimentation perspective, such a use case would enable the extraction of mobility partners or development/testing of attractive augmented reality applications.

4. REFERENCES

[Marks 2010] Gary Marks, "Precision Irrigation; A method to save water and energy while increasing crop yield; A targeted approach for California agriculture ", March 2010

[Smith 2009] Smith, Rod and Baillie, Justine "Defining precision irrigation: a new approach to irrigation management", Irrigation and Drainage Conference: Irrigation Today - Meeting the Challenge (IDC 2009), 18-21 Oct 2009, Swan Hill, Australia.

[USC 2009] USC Precision Agriculture. http://www.gpoaccess.gov/uscode/index.html, February 2009.

[Cooley 2009] Heather Cooley, Juliet Christian-Smith, and Peter H. Gleick, "Sustaining California Agriculture in an Uncertain Future", Pacific Institute, 2009.