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2020 CiViTAS
Cleaner and better transport in cities

DESTINATIONS

D2.4

Validation of smart metering systems for mobility data collection potentials

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Abstract

This deliverable D2.4 has the objective to describe the results of Task 2.6 - Smart metering and crowdsourcing – which includes the four measures implemented in Madeira, Rethymno, Elba and Las Palmas de Gran Canaria. Based on the description of the measures, a comparison is made on the following aspects: aim of the measure, type of data collected and with which device, and the client / end-user of the data who gets access to the data collected. All four pilots show that smart metering and data collection through new techniques offers many new possibilities. However, before collecting data, a monitoring and evaluation plan is a good start for the systematic collection of data and the sound analysis of this data to form it into useful information.

Project Partners

Organisation	Abbreviation	Country
Horários do Funchal, Transportes Públicos, SA	HF	PT
Agência Regional da Energia e Ambiente da Região Autónoma da Madeira	AREAM	PT
Câmara Municipal do Funchal	CMF	PT
Secretaria Regional da Economia Turismo e Cultura	SRETC	PT
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Ingeniería Electrónica Canaria S.L	INELCAN	ES
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Istituto di Studi per l'Integrazione dei Sistemi	ISINNOVA	IT

European Integrated Project	EIP	RO
Sustainable Services	GV21	ES
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Glossary

APM	Madeira Promotion Association
ARM	Autonomous Region of Madeira
B2A & B2B	Business to Administrators & Business to Business
IoT	Internet of things
ITS	Information Technology System
MaaS	Mobility as a Service
PT	Public transport
SUMP	Sustainable Urban Mobility Plan

1 Executive Summary

This deliverable is a result of Task 2.6: Smart metering and crowdsourcing. The aim of this task is to develop systems which will allow local authorities to collect real-time data on traffic and mobility, understand mobility patterns, anticipate needs of residents, tourists and target groups, and allow for dynamically adapting the SUMP based on evolving mobility demand and modal split. This deliverable focuses on a description of the measures in the four Destinations sites, the differences between the used tools, the outcomes of the measures and what impact it has on the SUMP approach.

In the four Destinations sites, measures have been implemented to test:

- **Funchal/Madeira - Smart metering, sensing and user generated content to improve urban mobility planning and services:** A set of smart sensors is installed to collect traffic and air quality data, with the main aim to improve planning, monitoring and control of mobility services. This measure is implemented to develop, monitor and enhance the SUMP taking into account the needs of both tourists and residents.
- **Rethymno/Crete - Smart systems for urban planners, PT operators and users:** Rethymno is using smart systems for urban planners to support decision making, monitor, assess and improve the SUMP action plan. The 11 thermal cameras and 5 meteorological stations provide real-time data about the traffic flow, mobility status in the selected spots including air quality. They provide valuable data set and notifications in case of unexpected events or irregular situations.
- **Elba - Elba open data layer:** An open data layer is designed to function as a support tool for the Sharing Mobility Agency. With this tool, it is possible to easily access data and information of all kind of mobility and touristic aspects. It is also a repository of data available for specific study requests.
- **Las Palmas de Gran Canaria - Smart destination:** For this measure, mobility data from mobile phones were collected, captured through the cell towers installed in the city. This data is later enriched with information from a survey conducted with tourists. The Municipality of Las Palmas de Gran Canaria will benefit from the data collected as it helps the Mobility Department in the drafting of the updated SUMP.

Based on the description of the measures implemented, a comparison is made addressing the following aspects/questions:

1) What problem / question will be solved?
2) What type of data is collected and with which device?
3) Who is the client / end-user of the data and how can they access it?

The measures tested in the destination sites all have a different way of collecting data and aggregating the data to information. All four pilots show that smart metering and data collection through new techniques offer many new capabilities to transport technicians, urban planners and high-level political decision makers. However, before collecting data, it is crucial to define the use of the collected information so they can feed different tools and process to support the decision at different levels: day by day traffic management or strategic planning and final decision.. A good monitoring and evaluation plan is an essential starting point to process the systematic collection of

data and to deliver a sound analysis to form it into useful information for the different final users (citizens, tourists, technicians and politicians).

2 Introduction

2.1 WP2 Objectives and Task 2.6

The objective of WP2 is to guide the six Destinations sites to establish and/or improve their own SUMP. This policy document guides the cities and regions to improve the liveability and transport situation for both citizens, stakeholders and for Destinations tourists.

Within the scope of the SUMP, the collection of data in the field of transport is essential for both the policy, the planning and the evaluation and monitoring process. Based on good data, it is possible to design adapted policies for the future, to implement new measures, to quantify outcomes and results and to evaluate the effectiveness of the implemented policy and measures.

The possibilities of data collection are improved with the introduction of smart metering, floating data collection and crowd sourcing. In this deliverable, a number of measures test the way data can be collected, analysed and used.

In WP 2 the task 2.6 addresses Smart metering and crowdsourcing. The aim of this task is to develop systems which will allow local authorities to collect real-time data on traffic and mobility, understand mobility patterns, anticipate needs of residents, tourists and target groups and allow for dynamically adapting the SUMP based on evolving mobility demand and modal split.

In four sites measures have been implemented to test:

- **Funchal/Madeira**: Smart metering, sensing and user generated content to improve urban mobility planning and services.
- **Rethymno/Crete**: Smart systems for urban planners, PT operators and users.
- **Elba**: Elba open data layer.
- **Las Palmas de Gran Canaria**: Smart destination.

Task 2.6 put together 2 successive steps:

1. Identification of systems to be used for crowdsourcing.
2. Setting up the tools for data collection.

This deliverable focuses on a description of the measures in the four sites, the differences between the used tools, the outcomes of the measures and the impact on the SUMP approach.

2.2 Objectives of Deliverable 2.4

This deliverable D2.4 has the objective to describe the results of T2.6 and the four measures in Madeira, Rethymno, Elba and Las Palmas de Gran Canaria. Furthermore, it will compare the

different tools and their ways of collecting data. The final objective is to give an insight into the value of the data and information collected and how they are relevant for the SUMP.

3 Smart metering and crowdsourcing (Task 2.6)

3.1 MAD 2.2 – Smart metering / sensing and user generated content to improve urban mobility planning and services

In MAD2.2 smart sensing/metering and user generated content is used to improve planning, monitoring and control of mobility services. The system tested makes use of generally available devices to sense and store urban data, related to urban accessibility, traffic and environmental indicators.

The infrastructure consists of a network of low-cost wireless sensors and webcams installed in strategic locations, at traffic lights and critical traffic spots, at the 4 main axes of the city along the main water streams and the waterfront, as shown in Figure 1. It is accessed from the web, including via smartphones. The main functions are counting (cars, people, cyclists) and monitoring (meteorological information, emissions and air quality). Information collected about traffic and environmental indicators can be used by the Municipality, SRETC, HF and other relevant stakeholders. Both systems provide access / viewing via a dedicated web platform.

Figure 1: Traffic counting cameras (top) and Environmental stations (bellow) installed in Funchal.

The **8 environmental monitoring stations** (3 installed and the remaining 5 to be installed following an expertise consultancy) were designed by ARDITI (Regional Agency for Research and Investigation) in order to be reliable, low-cost, portable, with an open HW/SW architecture, and highly competitive even among entry level commercial solutions. The stations collect and monitor indicators, namely: Carbon Dioxide (CO2); Carbon oxide (CO); Nitrogen Dioxide (NO2); Nitrogen Oxide (NO); Ozone (O3); Particles (PM2.5, PM10); and Sulphur Dioxide (SO2), plus Noise and Temperature, humidity, and air pressure (Figure 2). With that information the Municipality of Funchal is able to monitor key touristic and residential spots in the city and, if necessary, to implement tailor made mobility measurements campaigns, such as to limit car traffic in some areas.

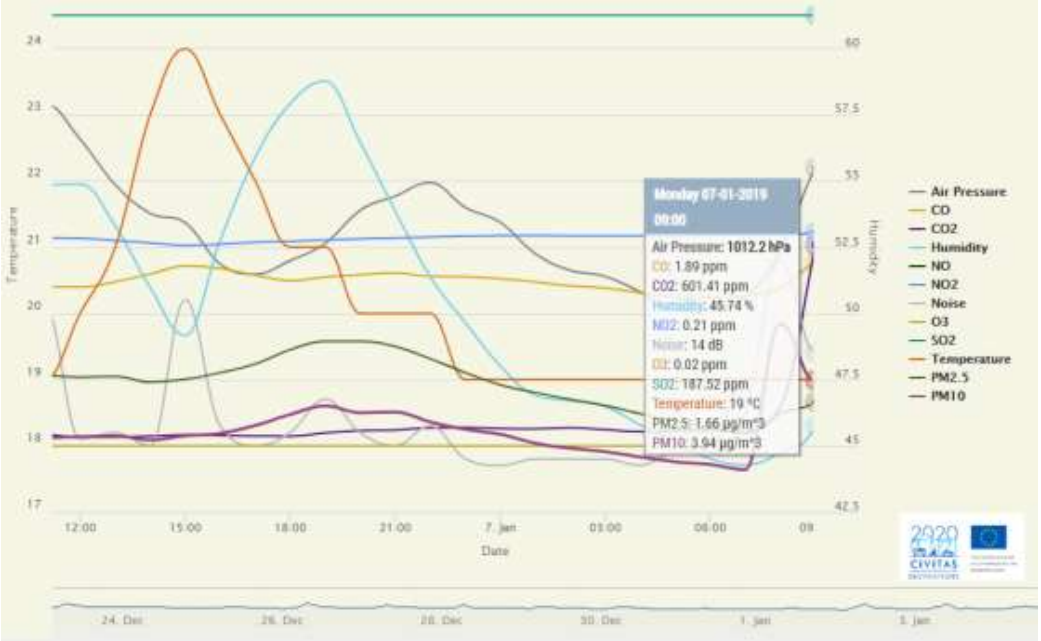


Figure 2: Environmental indicators as available to users

21 smart sensors (Figure 3), capable to screen mobility trends, were also implemented between 2018 and June 2019 in sensible tourist areas. The data on the mobility of tourists was recovered during the monitoring of the Beanstalk project, in partnership with the Madeira Promotion Association (APM). The crowd sourcing data collection was implemented in a passive way, meaning that the user was not actively providing data inputs to the platform, but his action was sensed and recorded by the system (although keeping users identity anonymous at all time). The final aggregated data was used by the APM to obtain information on tourist flows in the Autonomous Region of Madeira (ARM). The anonymous data was stored in ARDITI's server and the data collected during festivals helped the Municipality and Region to outline the civil protection plans related to these festivities and to make evaluation about numbers and distribution of audience.

Figure 3: Smart OpenWrt based sensor / router used to track mobility trends (with 4G mobile data pen)

The **3 automatic traffic counters** were installed in June 2018. The new network of traffic monitoring sensors monitors the three major inbound roads, leading towards the seaside. Collected data are sent to the data browser web platform, allowing Funchal Mobility and Traffic Division to inspect them in real time and to store them for chronological and thematic analysis. Following an evaluation of the system, and given the importance of traffic monitoring for mobility management and the decision-making process, the system will be further upgraded and expanded to other areas in the city.

The traffic counts must be analysed in the hourly period between 06:00 and 20:00 so that the peaks of greater traffic intensity assume a greater expression in the visualisation. In the following Figure 4, what is intended to be demonstrated is the typical daily traffic flow and the various components

of analysis of the counters (historical series, time indicators, modal split, speed, congestion parameters and traffic volume by road).

Figure 4: Data platform for the automatic traffic counters installed by the Municipality of Funchal

Figure 5: HF's bus routes and bus-stops analysed in Funchal

To count passengers on busses it was chosen the Wi-Fi tracking solution, which proved to be much more difficult to develop, implement and test than foreseen at the beginning. The passenger counting solution, based on the collected data from Wi-Fi sensors inside buses were analysed/compared to ticketing data in order to define a model, although early conclusions indicated that it was not feasible / fully reliable to use this approach to count passengers. The **passenger counting communication system** first approach, was through mobile data pens. This starting test failed. The second approach was based on fixed antennas, which didn't work as expected at first and had to be improved.

In June 2018, a database of collected data for traffic counts and modal split was created. Initially, it was planned to use this kind of data to compute personalised multimodal trip planning on the basis of the user's preferences and needs. Such capability it was not exploited in this specific measure, because it was realised that deploying and providing such infrastructure (hardware + data collection) was in itself highly demanding and that developing such a new complex service layer on top of that infrastructure wasn't feasible in the scope of the project. However, it provides a vast amount of data which can then be used to plan activities for the extended SUMP models.

In June 2019, **1 database of collected data related to greenhouse emissions and noise** was also created. From the collected data, reporting on mobility problems and the check of quality of life standards (e.g. air pollution levels) was done.

3.2 RET 2.2 – Smart systems for urban planners, PT operators and users.

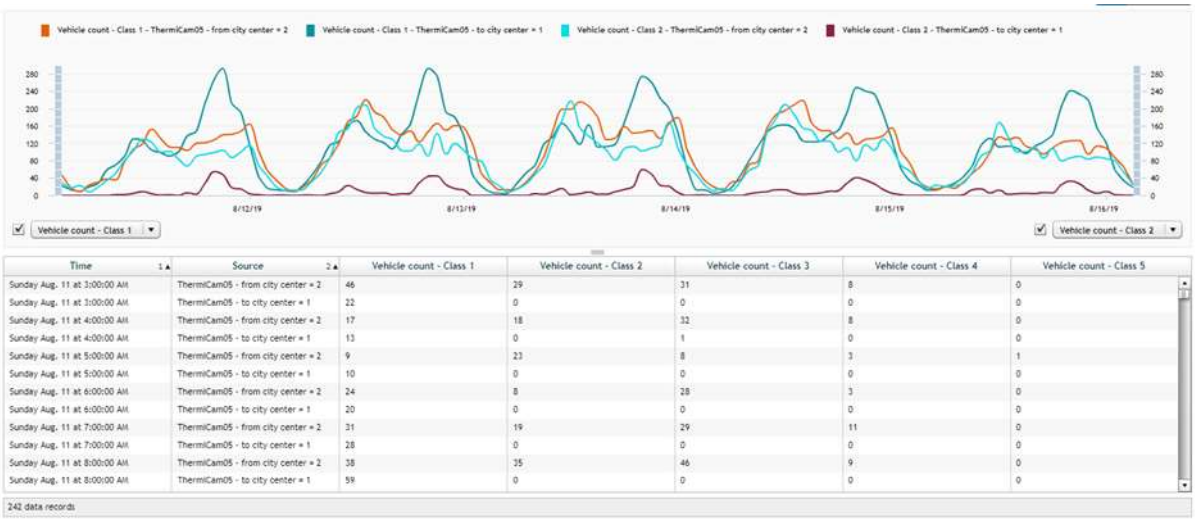
Figure 6: Thermal camera

Rethymno is using smart systems for urban planners to support mobility and traffic management, decision making and to monitor, assess and improve the SUMP action plan. In the framework of RET 2.2 - Smart systems for urban planners, PT operators and users - Rethymno installed 11 thermal cameras and 5 meteorological stations (Figure 6& Figure 7Figure 7) with integrated environmental sensors in selected city hotspots. With the cooperation of local mobility experts and the National Technical University of Athens, the city mobility and traffic flows were analysed, and 11 spots were selected in order to monitor all the mobility flows to and from the city centre. The Municipality also took into consideration the issue of potential sensitive personal data recorded by the system and decided to install a monitoring system using thermal cameras to avoid the potential issues of personal data while, at the same time, achieving better accuracy of the collected data. Thermal cameras do not need light to operate, but use the thermal energy emitted from vehicles and bicyclists. This enables the sensors to detect vehicles and bikes in the darkest of nights, over a long range and in the most difficult weather conditions. The result is reliable, 24/7 traffic detection for a wide range of applications.

Figure 7: Location of thermal cameras (blue) and meteorological stations (orange) in Rethymno

The Municipality published a tender for the procurement of a monitoring system consisting of 11 thermal cameras for real-time monitoring of the daily traffic. Combined with the thermal cameras system, TUC developed and installed 5 meteorological stations which, toghether with the data collected from the thermal cameras, can provide a complete picture of mobility in the city and evaluate the impact of different SUMP measures, tested both in terms of mobility and the environment.

The 11 thermal cameras are configured to monitor separate vehicles moving in each direction and traffic lane and categorise passing vehicles of different types according to their size. The IT platform can provide useful real-time information in the occurrence of unexpected events, such as abnormal or illegal movement of vehicles or other major events (traffic jams and so on), and also a detailed statistical analysis of the different indicators monitored by the system, using different integration levels and time spans (hour, day, month per hour, per day, per month etc.). Using a dedicated IT platform, all data are collected in real time and specific indicators are being monitored (average vehicle length, Density, Gap time, headway, street occupancy, average speed, and vehicle count). The platform can provide data reports for different time spans and periods of time according to our needs and produces event logs for traffic events (Figure 8).



Time	Source	Vehicle count - Class 1	Vehicle count - Class 2	Vehicle count - Class 3	Vehicle count - Class 4	Vehicle count - Class 5
Sunday Aug. 11 at 3:00:00 AM	ThermiCam05 - from city center = 2	46	29	31	8	0
Sunday Aug. 11 at 3:00:00 AM	ThermiCam05 - to city center = 1	22	0	0	0	0
Sunday Aug. 11 at 4:00:00 AM	ThermiCam05 - from city center = 2	17	18	32	8	0
Sunday Aug. 11 at 4:00:00 AM	ThermiCam05 - to city center = 1	13	0	1	0	0
Sunday Aug. 11 at 5:00:00 AM	ThermiCam05 - from city center = 2	9	23	8	3	1
Sunday Aug. 11 at 5:00:00 AM	ThermiCam05 - to city center = 1	10	0	0	0	0
Sunday Aug. 11 at 6:00:00 AM	ThermiCam05 - from city center = 2	24	8	28	3	0
Sunday Aug. 11 at 6:00:00 AM	ThermiCam05 - to city center = 1	20	0	0	0	0
Sunday Aug. 11 at 7:00:00 AM	ThermiCam05 - from city center = 2	31	19	29	11	0
Sunday Aug. 11 at 7:00:00 AM	ThermiCam05 - to city center = 1	28	0	0	0	0
Sunday Aug. 11 at 8:00:00 AM	ThermiCam05 - from city center = 2	38	35	46	9	0
Sunday Aug. 11 at 8:00:00 AM	ThermiCam05 - to city center = 1	59	0	0	0	0

242 data records

Figure 8: Vehicle count from one thermal camera in Rethymno

The data are being collected in a local server to support decision making for municipality experts, mobility planners and finally for politicians. The measure is not yet completed, although the cameras are installed and operating.

The software platform is used for traffic monitoring, event alerting and data reporting for mobility management. Specifically, it provides the following functions (Figure 9):

- Collection and storage of data and events generated by the video detectors
- Analysis and visualisation of traffic in real-time: monitoring, alerting and reporting
- Event filtering via scenarios running on related detectors
- Simultaneous streaming video from multiple cameras

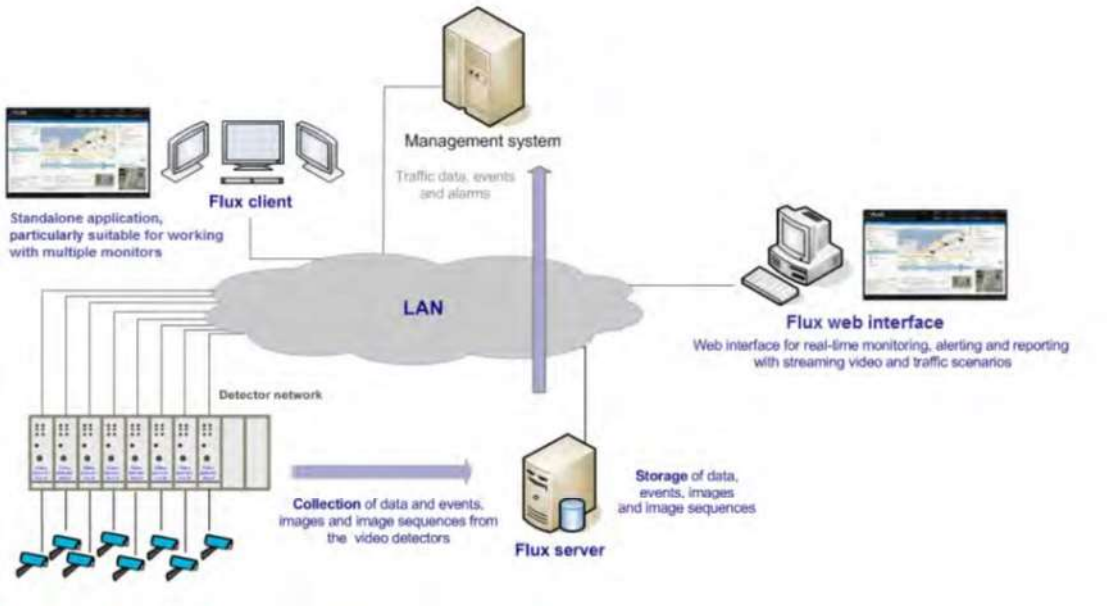


Figure 9: Architecture of software platform

The platform server can be accessed both by using the web interface and as a standalone application that connects to the server. This application has some additional features and allows to work with multiple monitors in an easy way. Data and events generated by the video detectors are transferred in real-time to the server. The platform stores these data and events in a relational database and makes them available for the Web Interface or the Client. The server can be accessed from any PC in the network, having a web browser.

In general, with the new system Rethymno is collecting and analysing numerous data sets to continuously support urban planners for decision making, monitoring, assessment, and the improvement of its SUMP action plan. In the following months, a new SMART Car Parking Management System, IT platform and smart applications to support a central monitoring system for efficient mobility management will be operated. Using the monitoring systems, valuable information is collected to help monitor the SUMP measures and proactively design action plans to help promote sustainable mobility solutions and traffic management. It is for the first time that the municipality gained access to real-time mobility data in the city, which is of significant importance providing the ability to study and design potential solutions based on concrete real-time data, and also to test possible solutions and mobility measures monitoring the actual impact of the tested measures.

3.3 ELB 2.2 – Elba open data layer

The ELB2.2 measure is strictly related to the ELB4.1 measure (Elba Sharing Mobility Agency) and to the others representing specific components of the Agency itself:

- ELB4.2: Car/scooter/bike/boat sharing
- ELB4.3: Ride Sharing Platform
- ELB4.4: Increasing feeling of safety among Elba Sharing users

The connection among the ELB2.2 and the above-mentioned measures is due to the fact that the Open Data Layer is actually a component of the Agency and it has been implemented concretely together with these measures.

Taking into account functionalities and use cases, the Sustainable Urban Mobility Agency is made of the following macro-components:

1) Ride sharing planning and management
2) Info-mobility Services
3) Operator Networking
4) Open data layer (ELB2.2)

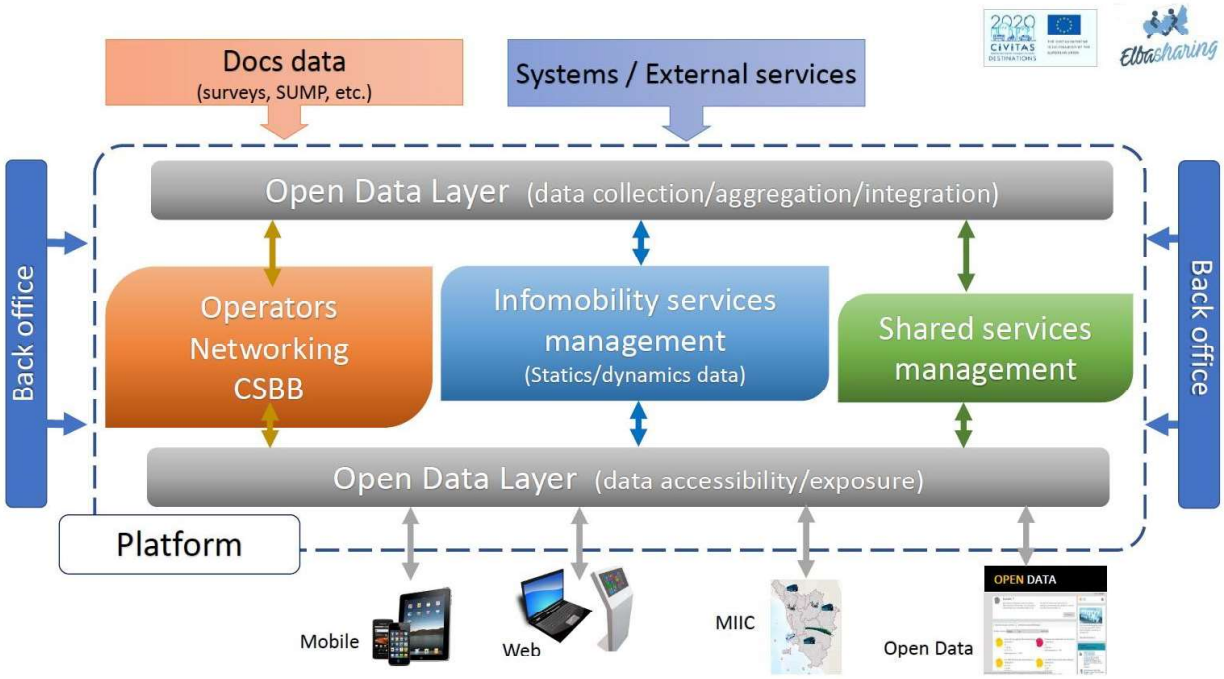


Figure 10: Architecture of the platform

The Open Data Layer is the macro component focused on information collection and data presentation/accessibility on the different mobility and transport services operating on the Elba Island. On one hand, this component collects and integrates the data coming from the different systems/services/procedures active on the network (including documents in the different formats/standards); on the other hand, this component homogenises and exposes this data for:

- The provision of “multimodal” info-mobility services (such as journey planner, static and dynamic information on mobility service) to be provided to citizens and visitors on APP and web portal in an aggregated way
- The provision of a centralised set of data, which be accessed by different users/actors (i.e. third-party developers for the implementation of new applications, mobility consultants for the development of mobility study, Public Administrations for mobility planning purposes)

Data collected are made accessible in open data format or through dedicated access by an appropriate user profile depending on the type of data.

The Elba Open Data Layer is the key component of the platform (Figure 10). This component was planned in the WP2, but is realised with measure ELB4.3.

A synthesis of the functionalities design per macro component is briefly reported below (Figure 11):

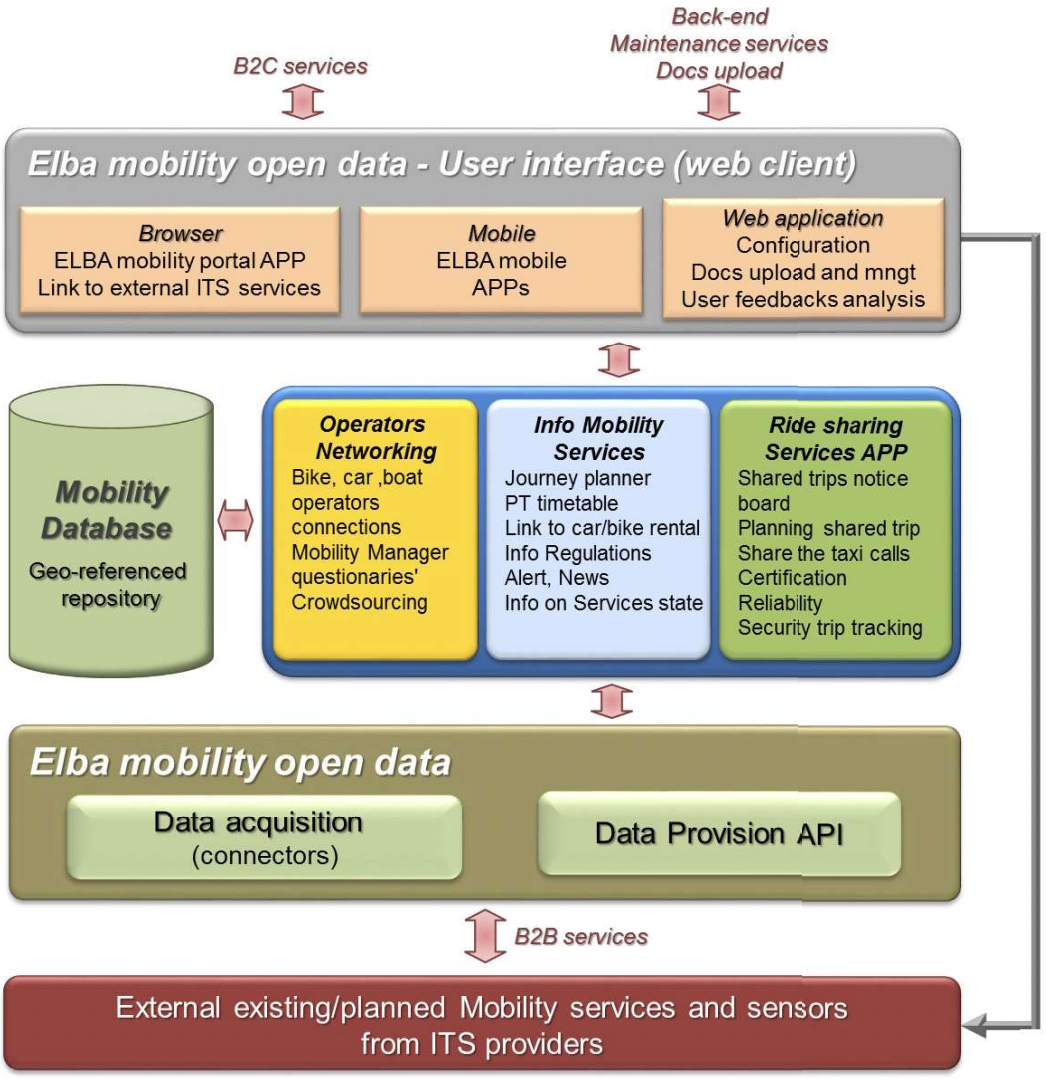


Figure 11: Functionalities design

Three levels of functionalities have been specified for the Open Data Layer:

1) *Collection of the different information typology and elementary data*

Automated direct collection of the data and information generated by the different ITS systems and mobility services or made available by the different authorities/entities managing or contracting the different mobility and transport services. The modalities for collecting information (static, semi dynamic and dynamic) could be different depending on the typology of data source, such as:

- Automated data collection from data sources and ITS repositories
- Data gathering through crowdsourcing campaigns or online questionnaires' management;
- Data provided manually by mobility operators;

- Data related to the use of agency services and APP/web portal functionalities (i.e. number of shared trips, O/D of the shared trips, etc.);
- Documents uploading (surveys implemented, mobility plans and related policies, SUMP documentation, etc.).

A number of data regarding the mobility services available on the Elba Island has been already collected by feeding the platform: detailed information and data regarding rental operators working on the island, private and public parking areas, transport operators, etc. have been collected and entered in the system.

Currently, the Open Data Layer contains detailed data of all the mobility services available on the Elba Island, both private and public. For example: the localisation of parking areas on the island and the number of parking lots (total/available); the number and localisation of rental shops and the number of vehicles available, etc.. All this information has been entered manually and, from now on, it can be directly updated by the mobility operators (parking or rental companies) accessing the platform by a dedicated user profile. In addition, the Open Data Layer collects the static data of the bus service operated in Elba connecting the Piombino harbour (mainland connection to/from Elba) with the closer cities and the static/dynamic information related to railway services to/from Piombino. All this data is gathered automatically through interfaces from the systems of the mobility operators.

Data format and interface specifications have been defined for the mobility services/systems which do not currently operate in Elba (i.e. traffic sensors, Parking Management Systems, etc.), so that they may be integrated later on into the Agency platform.

Documents uploading is working and it is carried out each time a document (SUMP, surveys, etc.) is declared to be accessible by external actors (i.e. other Administrations, consultants, mobility experts).

Data gathering through the publication of on-line questionnaires is already implemented but any on-line consultation has been launched so far (also for the COVID crisis).

2) *Aggregation and integration of the information and data*

- Realisation of a centralised and unique geo-referenced database;
- Realisation of a documentary archive;
- Elaboration and aggregation of the info and data, making standardised structured data available.

The information and data (static, semi-dynamic and dynamic) to be collected refer at least to these different domains: parking area capacities, public transport timetables (bus, ferries, railway services), bike/car/scooter rentals (vehicles availability), EV recharge stations, etc.,

3) *Exposition/Publication/Accessibility to data and information*

- Formatting of the data for the provision of aggregated multimodal info-mobility services available for citizens and visitors on APP and web portal

- Formatting and exposition of the data and provision of the service to third party (B2B services: i.e. open data for the development of third party application);
- Exposition and accessibility of the documents stored into the database by the Authorities and third part users (B2A and B2B services: i.e. Elba Municipalities, the Province of Livorno, the Regional Administration – B2A or mobility experts, consultants – B2B).

By virtue of the Open Data Layer, the Platform could be also considered as a fundamental tool for mobility observatory for the overall Elba Island. Indeed, the Open Data Layer records the information produced by the operating Agency and the use of its services by end-users: in particular, the Open Data Layer can record and store two types of data: 1. level of use of the Agency's functionalities and services; 2. the mobility of users, by trip sharing (management of shared services).

Therefore, the Open Data Layer is surely a strategic planning support tool for local administrations and decision makers, because it would make available and easily understandable the data regarding mobility habits of residents and tourists; in addition, it is supposed to be a good tool to receive information by the providers of mobility services.

3.4 LPA2.2 - SMART destination

The CIVITAS DESTINATIONS project gave the opportunity to assess and analyse the tourists' mobility behaviour in Las Palmas de Gran Canaria (measure LPA2.2). To do so, tourists' mobility was tracked using data from their mobile phones, which was captured through the cell towers installed in the city. This way, information such as itinerary, distance travelled and time spent at each spot for different tourists' profiles, can be obtained.

The data collection was done in November 2019 (mixing working days and weekends). The integration of the data collected by tracking and the surveys (described in detail in D2.3) expected to provide reliable information about tourists' mobility behaviour in the city of Las Palmas de Gran Canaria and on the whole island.

Some of the expected outputs are: origin-destination matrix, most visited hotspots in the city, duration of the touristic visits depending on the purpose (cultural, shopping, etc.), mobility behaviour, knowledge and awareness about the public transport offer in the city, identification of the main gaps regarding the offer of sustainable mobility alternatives for tourists, etc.

The information is used by operators like Guaguas Municipales, the public transport operator, and Sagulpa, the public parking company also in charge of the bike sharing scheme. Both of them can use the information to better plan their mobility services. The Municipality of Las Palmas de Gran Canaria will benefit from the data collected, especially the two departments that are directly concerned:

- The Mobility Department: the data collected will help them in drafting the updated SUMP (linked to LPA2.1) in areas such as the new bike-lane network, traffic-calming zones, new parking management scheme, etc.
- The Tourism Department: the Tourism Board of the Municipality carries out surveys from time to time, but they do not have a thorough knowledge about tourists' mobility patterns and behaviours.

The mobile phone tracking system that has been used to identify tourists' flows and travel patterns is described in the following steps:

1) At first, the tracking system was based on the installation of a smart metering system in the Laboratory Area. A smart meter is an electronic device that records real-time or near real-time data about mobile phone flows and movements. However, major Spanish telecom operators, such *Telefónica* and *Orange España*, have developed new services and business models to monetize their data in the recent years. After having conducted a comprehensive market research, this solution has been identified as the best one on the market to obtain rich mobility information about tourists in the city. Besides this, using mobile phone tracking data allows to expand the study to the whole city and not only focus on a small area.

2) After having decided that the pilot would be based on mobile phone tracking data, a benchmarking assessment of similar ongoing projects was carried out. Despite having barely found any experiences based on mobile phone tracking data, the main transit operator of Tenerife (TITSA) has been contacted. TITSA has entered into a public private partnership with Orange to develop a new business model based on mobile phone data analytics, and explained some details about their project about tourist mobility.

   The approach to assess tourists' flows and mobility behaviour in Las Palmas is based on crossing two information sources: the street survey to tourists (WP2/WP9 task of CIVITAS DESTINATIONS) and the mobile phone data tracking. In Spain, the best value-for-money option to get this mobile phone data is to buy it directly from telecom operators. Therefore, the service of Orange was subcontracted, which is the third largest telecom in the country that offers a service based on collecting and analysing anonymised geolocation data from mobile devices.

3) However, the quality and accuracy of the geolocation data from mobile devices have to be carefully validated. In fact, it has to be blended with other data in order to provide rich demographic and mobility information. To do so, together with Orange, additional data was collected to obtain good-quality information to fine-tune and validate the model:

- data from the Port Authority: forecast and schedule of cruises and regular ferries;
- data from the Tourism Observatory of Las Palmas de Gran Canaria: visitors arrivals, visitors expenditures, occupancy rates, length of stay, etc.;
- data from the public transport company (Guaguas Municipales): data from the ticketing system (users of the *1-day card* and the *3-day card*);
- land use data (SIOSE)
- population data (INE)
- data about tourist movements on borders (FRONTUR-INE);

  Only anonymised data is being used to carry on this project and the mobile phone data provider ensures that no personally identifiable information can be recovered. The information delivered includes only aggregated activity and travel information, so that the privacy of personal data is fully guaranteed.

4) After determining the period of study, the following step was to define the zoning. The city of Las Palmas, as well as the rest of the island, was divided in small polygons/zones that

are the origin and destination for tourists' displacements. Each one of these zones is covered by one or more cell towers that detect the mobile phones present in that area.
The final zoning scheme had a link with the zoning proposed by the Mobility Office of Las Palmas for their models and it also took into account the location of the main touristic attractions and hotspots. Where the density of touristic hotspots was higher, the zones were smaller, so the results of the O-D matrices could be more reliable and accurate.
At the same time, the target group (tourists) was divided into three subgroups, in order to better characterise the differences in the behaviour. The first group included the cruise passengers that made a stop in Las Palmas de Gran Canaria, the second one included the cruise passengers that start or end their trip by cruise in the city, and finally, the third one included all those tourists that are in the city of Las Palmas de Gran Canaria and do not fall in any of the other 2 groups.

5) Once these parameters are defined, the data collection process can start. The data analytics algorithms to obtain tourists' flows and mobility behaviour information is based on the following tasks:

- Pre-processing and data debugging
- Sample identification
- Address and work place of the Spanish tourists
- Characterisation of the foreign tourists (basic features)
- Characterisation of the cruise tourists (basic features)
- Trips and flows identification
- From sample to population (different approach for Spanish tourists and foreign tourists)
- Data accuracy check using other data sources (mentioned before)
- KPI calculation

Orange provides information based on a sample of the total population, and therefore the way activity and mobility information is expanded is of paramount importance. As explained before, they address this issue by means of proprietary algorithms that combine the data from mobile devices with data extracted or inferred from other sources to build a representative sample and expand it to the total population under study.

Finally, it is still under discussion how the data from the street survey to tourists (WP2/WP9 task of CIVITAS DESTINATIONS) could bring added-value to this methodology.

4 Setting up tools for data collection

4.1 Introduction

Cities generate huge amounts of raw data. Transition to a smart city crucially depends on harvesting and using existing urban data to support decision making and to identify trends to improve city governance. In this perspective, it is of main importance that the data is transformed to information to guide decision makers and to empower citizens and tourists determinations.

Good transport research relies heavily on the existence of good data, which must be collected and stored in a proper way.

Within the policy cycle of a SUMP, the research based on traffic and transport data is characterised by at least 3 stages:

- Analysing the current situation and signalling problem areas.
- Analysing the effect of implemented measures: evaluation.
- Monitoring of your policy.

The development and implementation of smart metering/sensing systems - Counting (for example cars, people, cyclists) and Monitoring (meteorological information, emissions and air quality) - brings innovation to the city and its mobility planning and monitoring, providing innovative decision support tools that allow:

- Establishment of correlations between the values measured and the traffic intensity/counts measured initially in the sensor stations.
- Decision support tools for the municipalities in the scope of mobility and environment;
- Making the information relative to the indicators available to the citizens
- Efficient, reliable, replicable, low-cost, continuous view of the urban environment;
- Analysis of the environmental impact of transportation;
- Collection of data leading to effective evaluations and monitoring.

Before collecting data, it is crucial to define what will be done with it and the related information. A good monitoring and evaluation plan have a paramount role to drivethe systematic collection of data and its sound analysis to form it into useful information. Within cities, generated information can be useful for different stakeholders and at multiple levels.

The following questions address the logical sequence should be followed todefine a sound data-collection and analysis structure:

1) What is the problem / information need and for whom?
2) What is the aim of the data collection and the related possible outcomes?
3) What type of research / form of data collection is best to get the data?
4) Execute the data collection (statistics: take into account the number of the sample: accuracy and reliability).
5) Analyze data: what information is the outcome?
6) How to report and to whom?

For the four project measures, a comparison will be made to analyse them and the related outcomes. An additional aim of this D2.4 is to compare the measures and their effectiveness and the possibilityy to combine them for a new situation in the future.

4.2 Comparison of the measures

In this paragraph, based on the description of the measures, a comparison (differences/equalities) is made on the following aspects (see **Erro! A origem da referência não foi encontrada.**):

1) Aim of the measure: What problem / question will be solved?
2) What type of data is collected and with which device?
3) Who is the client / end-user of the data and how can they access it?

All aspects will also be related to the SUMP and its development cycle.

In **Funchal/Madeira,** a set of smart sensors is installed with the main aim to improve planning, monitoring and control of mobility services. In fact, this measure is implemented to support and develop the SUMP, by taking into account the needs of both tourists and residents. In addition, the planning and services for mobility in Funchal are improved, considering both residents and tourists, using innovative passengers counting schemes and mobility sensors.
The aim is to have positive cost-benefit results after deploying the smart sensors (environmental stations and mobility sensors) network, compared to standard methodologies and to achieve a high sense of usefulness among decision makers. The deployment of sensors provide quantitative, historical, reliable and as close as possible real-time data on mobility and environment indicators. As for citizens and tourists, although they cannot access the platform, the data gathered will be tailored for awareness events to showcase the impact of road restriction policies on the environment and local economy, as well as to foster the transition towards soft modes. During the COVID-19 pandemic mobility patterns in Funchal were collected with the smart sensors network, on such evidences they were published several articles based on the data gathered. The data collected by the automatic traffic counters is displayed on a cloud server, in which the Municipality can set a graphic layout based on specific parameters, such as passages, modal split, speed and occupancy. As for the environmental sensors, the data is accessed through a webpage and stored in a database for monitoring and historic recording.

Recommendations

A lot of data is gathered and processed in Madeira, via different sensors and sources. This information is now used by the Municipality and the transport company to improve services. Some data are available for the public. It would be worthwhile to share the information wider than via a website. Now it is just giving data, but not really information related to, e.g., policy, (expected) values and deviations. The information can be displayed via apps, websites or information screens in the city or, e.g., in the bus.
The combination of measuring the air quality and the mobility situation could be transferred to other cities/sites with a high density of vehicle traffic, causing a bad quality of air.

The combination of measuring the mobility situation and the air quality has also been used in **Rethymno/Crete**, which is monitoring the daily traffic with 11 thermal cameras and 5 meteorological stations, with integrated environmental sensors, located in selected city hotspots. The 11 thermal cameras are configured to monitor separate vehicles moving in each direction and traffic lane, and categorise passing vehicles of different types according to their size.

Rethymno is using smart systems for urban planners to support decision making, monitor, assess and improve the SUMP action plan. By using a dedicated IT platform, all data are collected in real time and specific indicators are being monitored (average vehicle length, density, gap time, headway, street occupancy, average speed, and vehicle count).

The 11 thermal cameras provide real-time data about the traffic flow and the mobility status in the selected spots, providing valuable information and notifications in case of unexpected events or irregular situations. Since it is the first time such a monitoring system is installed in the Municipality, the data are being collected and stored in a local server and are analysed and used mostly for decision making and the testing of different measures and interventions. In the near future, the plan of the Municipality is to provide access and make the data available to other authorities, experts

and research institutes, such as the traffic police department, the technical department of the Region of Crete and the University of Crete. After the smart Parking Management System is installed, the Municipality of Rethymno plans to integrate the information provided, thus making more data available to citizens and tourists to inform them.

Recommendations

Rethymno is collecting a lot of data by monitoring traffic and air quality in real time. Since it is the first time that Rethymno collects data by installing a monitoring system, it is reasonable that the data is not immediately provided to other authorities or made available to citizens and tourists. At a later stage, it is recommended to share data with the public.

The air quality was measured at different locations compared to the locations where the thermal cameras were located to count vehicles. To combine the traffic data with the air quality data, it would have been easier to locate them at the same locations. However, in the case of Madeira, the merging of both data sources led to unsatisfied results showing a lack of correlation. This is due, most probably, to the fact that the sensors were not deployed accordingly to the spatial conditions.

Another recommendation would be to combine parking data and the inputs gathered from traffic counting. Traffic could be reduced if there is better knowledge on free parking spaces.

To improve the cycling situation in Rethymno, raising awareness is important. This could be done with cycle counters (as already implemented in several European cities) to show the number of cyclists passing at a specific location in a day/month/year.

For the **Elba Island**, an open data layer is designed to work as a support tool for the Agency. With this tool, it is possible to easily access data and information of all kind of mobility aspects. Data can be used by different end-users: municipalities, citizens and tourists, and network operators and ride-sharing services. All users have different access to different data.
This open data platform is very sophisticated. All kind of data, collected by different sensors and sources can be uploaded, and information can be communicated via, e.g., mobile phone or a website. The architecture of the platform is crystallised and ready to be implemented.

Recommendations

The Open Data Layer is a usefull platform to share big data with several end-users, especially as it is an open data platform. It is an easy task to collect different types of data and to go from data to information. However, it is more challenging to share the information with end-users and to make a change, e.g., in the mobility behaviour of citizens and/or tourists.

It might be useful to develop on the information given from the open data platform, an alternative Mobility as a Service (MaaS), while concentrating on customers' needs, and offering personalised or tailored and comprehensive solutions. This would be especially useful for the citizens and tourists on the Elba Island to organise their mobility. Offering a service with customer/user/traveller transport needs and offering integration of transport services, information, payment and ticketing would be the main focus.

Las Palmas de Gran Canaria concentrated on collecting mobility data from mobile phones, captured through the cell towers installed in the city. It is an anonymised geolocation data from mobile devices. This data is later enriched with data from a survey conducted with tourists. The survey gathered qualitative information about their stay, travel behaviour and the visitor's profile.

With the mobile phone data, it is possible to study the movement of tourist and citizens around the island. However, it is not possible to identify if the owners are citizens of the city of Las Palmas, workers or tourists. Based on the processed data, conclusions can be made whether if it is a tourist or citizen. From the data, a lot of mobility data, location data and tourist data can be traced. The mobile phone data has been used to identify the most visited areas (using heat maps). This information will be used for future transportation planning, in order to improve the tourists' accessibility to sustainable mobility services (public transport, bike sharing, etc.).

The on-street surveys will be used to improve the following issues, according to the needs and requirements of tourists: the public transport map, the "*LPA movilidad*" App, Sagulpa and Guaguas Municipales own Apps, the on-foot guided tours, the bike-sharing scheme (*Sítycleta*), the bike guided tours, the tourist-oriented travel fares (LIVE ticket), the touristic bus, etc.

The information is used by the operators, like the public transport operator and the public parking company also in charge of the bike-sharing scheme. Both can use the information to better plan their mobility services. The Municipality of Las Palmas de Gran Canaria will benefit from the data collected as it helps the Mobility Department in the drafting of the updated SUMP, which concerns, e.g., the new bike-lane network, traffic-calming zones, new parking management scheme, etc.

Recommendations

In the case of Las Palmas de Gran Canaria, quantitative and qualitative data (mobile phone data with survey data) were combined. The main benefits of the collection of the data while doing surveys is the volume of the sample; lower costs than other traditional survey systems; the quick process and the precision of the data. Another benefit is to buy data from other companies, as it was done in this case by purchasing mobile phone data from Orange. This is the best solution on the market to obtain rich mobility information about tourists in the whole city, and to expand the study to the entire urban centre and not only focus on a small area.

As proposed above for Elba, more tailor-made solutions – such as MaaS - with special attention on tourists, could be developed. Based on the data collected, multimodal and demand-responsive mobility services, offering citizens or tourists tailor-made or personalised travel plans through a digital platform, could be developed. Those could provide real-time transport information, payment and transaction processing for the different hotspots of Gran Canaria.

Aim	Devices/Tools	Clients/End-users	Data/Measurements	Storage/Platform
Funchal/Madeira				
Improve planning, monitoring and control of mobility services.	8 Environmental monitoring sensors	Information for Municipality: used to monitor and, if measurements exceed the given limits, other measures will be implemented. Data tailored for awareness activities geared to several target groups.	Meteorological information: Temperature, humidity, air pressure Emissions and air quality: CO2; CO; NO2; NO;O3; PM2.5, PM10; SO2,	Database used by Municipality. Air quality data in real-time on a webpage.
	21 smart sensors	Information for Municipality	Tourists flows during festivals based on estimated concentration of people in specific spots/locations and on analysis of mobility patterns of tourists at their destinations.	
	3 automatic traffic counters	Information for Funchal Mobility and Traffic Division: used to monitor and, if numbers exceed levels, to take other measures into action.	Traffic data in real time (Traffic flow, speed, modal split)	Data are sent to a data browser web platform in real time.
	Passenger counting in PT buses with Wi-Fi	PT operator	Number of passengers in the bus	

Aim	Devices/Tools	Clients/End-users	Data/Measurements	Storage/Platform
Rethymno/Crete				
Support decision making, monitor, assess and improve the SUMP action plan	11 thermal cameras	Municipality of Rethymno / TUC	Average vehicle length; Density; Gap time; Headway; Street occupancy; Average speed; Vehicle count	IT platform can provide: real time information; detailed statistical analysis of the different indicators (per hour, day, month); data reports for different time spans and periods of time, event logs for traffic events.
	5 meteorological stations with integrated environmental sensors		Meteorological information: Temperature, humidity, air pressure Emissions and air quality: CO2; CO; NO2; NO; O3; PM2.5, PM10; SO2,	
Aim	**Devices/Tools**	**Clients/End-users**	**Data/Measurements**	**Storage/Platform**
Elba				
Permanent support tool for the Agency Repository of data available for specific study requests	Automated data collection from data sources and ITS repositories; Data gathering through crowdsourcing campaigns or online questionnaires' management; Data provided manually by mobility operators	Private and public clients (open data); Elba Municipalities; Province of Livorno; Regional Administration	Localization of parking areas and number of parking spaces; Number and localization of rental shops and the number of vehicles available; Public transport timetables;	Elba Open Data Layer is the key component of the platform. Presentation and accessibility of the documents stored into the database by the Authorities and third part users.

Aim	Devices/Tools	Clients/End-users	Data/Measurements	Storage/Platform
Las Palmas de Gran Canaria				
Assessment and analysis of tourists' mobility behaviour by tracking tourists' mobile phones	Anonymised geolocation data from mobile devices	Municipality of Las Palmas de Gran Canaria; Guaguas Municipalities; Sagulpa	Itinerary; distance travelled; time spent at each spot for different tourists' profiles; Type of visitors; Age and gender (only from national customers and no roaming customers); Sequence of visited areas, overnight stay and length of stay	Database with anonymised data
	Surveys: Tourists` needs and requirements, preferences, opinions		Qualitative information about visitors' stay: mode of arrival, location, number of persons traveling Travel behaviour during their stay: transport mode, preferences, etc. Visitors' profile: gender, age, profession, country of residence, purpose of their travel, etc.	

Table 1: Comparison between the different tool

All the measures above contribute to Big Data, a great quantity of diverse information delivered in increasing volumes. The expansion of the Internet of Things (IoT) has resulted in an important amount of heterogeneous data that are produced at an exponential rate.

However, what matters is the use purpose of the big data. The data can be analyzed for insights that lead to better decisions.

In the case of Funchal/Madeira and Rethymno/Crete, the data collection is performed by wireless sensor networks. The sensors' size, costs, variety and the advances in wireless communication technology, allow to realise, for example, measures as the ones implemented by Funchal and Rethymno. The main function is to count traffic/cars and monitor (meteorological information, emissions and air quality). In case of Funchal/Madeira, both data were merged although the results were unsatisfactory, showing a lack of correlation. This is due, most probably, to the fact that the sensors were not deployed accordingly to the spatial conditions, given the lack of skills in handling environmental stations. Therefore, an expertise consultancy will be carried out to empower the Municipality with the necessary skills to manage the environmental stations and analyse the data.

In the case of Las Palmas de Gran Canaria, the data was sensed by the mobile phones of the visitors. This allows to observe the individual and collective behavior of people. In this case, the itinerary, distance travelled and time spent in hotspots by citizens and tourists were measured. This allowed to analyses the mobility behavior and identify the main gaps regarding the offer of sustainable mobility alternatives for tourists, etc. However, the quality and accuracy of the

geolocation data from mobile devices had to be carefully validated. In fact, this data has to be blended with other data in order to provide rich demographic and mobility information.

Both data sources are complementary but cannot be combined. Mobile phone data let us quantify the total number of visitors and to track their travel patterns inside the study area, while surveys let us obtain a more qualitative information about the visitors (needs and requirements, preferences, opinions, etc.).

In the case of Elba, a multiplicity of data sources are used to integrated the Open Data Layer of the Elba Island. The Open Data Layer contains detailed data of all the mobility services available on the Elba Island, both private and public. The data can be either entered manually (also directly updated by mobility operators), or gathered automatically through interfaces from the mobility operators' systems. Data format and interface specifications have been defined for the mobility services/systems which do not currently operate in Elba (i.e. traffic sensors, Parking Management Systems, etc.), so that they may be integrated later on into the Agency platform.

The table below (Table 2) presents the data acquisition done by the different Destinations sites, gathering the elementary data, the data fusion, which merged the gathered information from heterogenous sensors to be put into a single platform, and for what reason it is used.

Destinations Sites	**Data acquisition**	**Data fusion**	**Knowledge and decision making**
	Elementary data	**Merged data**	**Response**
Funchal/Madeira	Environmental sensor data: temperature, air pressure, air pollutants Count devices data: traffic flow, modal split, speed, road occupancy and bus occupancy	Both data were merged although the results were unsatisfactory, showing a lack of correlation.	Traffic control and air quality monitoring: identification of hotspots of heavy traffic and bad air quality.
Rethymno/Crete	Thermal cameras: average vehicle; length; density; gap time: headway; street occupancy; average speed,vehicle count Environmental stations: temperature, humidity, air pressure, air pollutants		Traffic control: real-time information, in the occurrence of unexpected events such as abnormal or illegal movement of vehicles or other major events (e.g. traffic jams)

Elba	Localisation of parking areas and number of parking spaces; number and localization of rental shops and the number of vehicles available, etc.		Collection, aggregation and accessibility of data and information on mobility and services available on the island
Las Palmas de Gran Canaria	Cell-phone data captured through the cell towers installed in the city: itinerary, distance travelled time spent at each spot for different tourists' profile Surveys: Tourists` needs and requirements, preferences, opinions	origin-destination matrix, most visited hotspots in the city, duration of the touristic visits depending on the purpose (cultural, shopping, etc.), (in form of aggregated activity and travel information, so that the privacy of personal data is fully guaranteed)	Mobility behaviour, identification of the main gaps regarding the offer of sustainable mobility alternatives for tourists, etc. knowledge and awareness about the public transport offer in the city,

Table 2: Data architecture overview

5 Conclusions

Collecting data in new, innovative ways offers a wide range of opportunities for both mobility and tourism. All the measures taken in the CIVITAS DESTINATIONS sites have different characteristics and a different way of collecting data and aggregating the data to information. All four pilots show that smart metering and data collection through new techniques offer many new possibilities. Collecting large amounts of data becomes much easier and also significantly cheaper. All the data collected and examined converge to the overall objective of develop, monitor and improve local Sustainable Urban Mobility Plans

Good data and valuable information can help local authorities to further implement their SUMPs. The data can be helpful in drawing up the plans, passing on measures' packages, monitoring and evaluating the implemented aspects. The aim of a SUMP is to ensure, in the long term, that a city is and remains liveable and attractive for its inhabitants, workers and visitors, especially tourists. An important element in the future of certain tourist destinations is to guide citizens and tourists to a less car-oriented holiday. This requires a change in behavior, which starts with proper information on sustainable modes of transport. Good data collection and distribution can contribute to good information. A tourist is often new to its destination. By communicating information in a timely and fast manner, for example, the modal split can be affected.

Specifically, per site, the following can be concluded:

Funchal/Madeira has gathered data via a set of smart sensors, both environmental and traffic data. The data is used to plan activities for the extended SUMP models. Furthermore, the data is partly published via websites. The combination of measuring the air quality and the mobility situation is highly valuable and it could be transferred to other cities/sites with a high density of vehicle traffic, causing a bad quality of air.

Rethymno has gathered traffic count data with thermal cameras, combining it, as it was done in Madeira, with air quality sensors. This was the first time the Municipality of Rethymno has set up a smart metering system and the experience was positive and ready to be upscaled in other cities and areas. This is especially useful due to real-time information, and in the occurrence of unexpected events such as abnormal or illegal movement of vehicles or other major events (e.g. traffic jams). This data could also be made available to the public (citizens and tourists) to raise awareness about the mobility situation in Rethymno.

Elba has the most integrated plan, where the starting point is to create a data platform for mobility. The aim is that transport providers, users and policy makers alike have access to the mobility database. The information is accessed through apps and web apps. In order to achieve an integration between the different mobility services, a MaaS system can be a good next step.

Las Palmas de Gran Canaria conducted a quantitative data collection (cell-phone data captured through the cell towers installed in the city) together with a qualitative data collection (surveys). With the mobile phone data (anonymised), it was possible to study the movement of tourists and citizens around the island. The Municipality of Las Palmas de Gran Canaria will benefit from the data collected as it helps the Mobility Department in the drafting of the updated SUMP, which concerns for example, the new bike-lane network, traffic-calming zones, new parking management scheme.

In general, it can be said that the collected data can be used even better than it has been done so far in the four sites. Here "golden rules" to set a proficient mobility data collection system:

- Pre-preparing a data collection plan, designed to determine which data is collected and for which purpose it can be used.
- Determining the value of the data for end-users. In many cases, the data collected is mainly used by policy makers or road managers. By making the data also available to road users, for example citizens or tourists, their mobility behavior can be addressed.

Combining data sources and information. For example, by linking data on air pollution with traffic intensities, links can be identified, which are helpful in, e.g., evaluation studies or monitoring