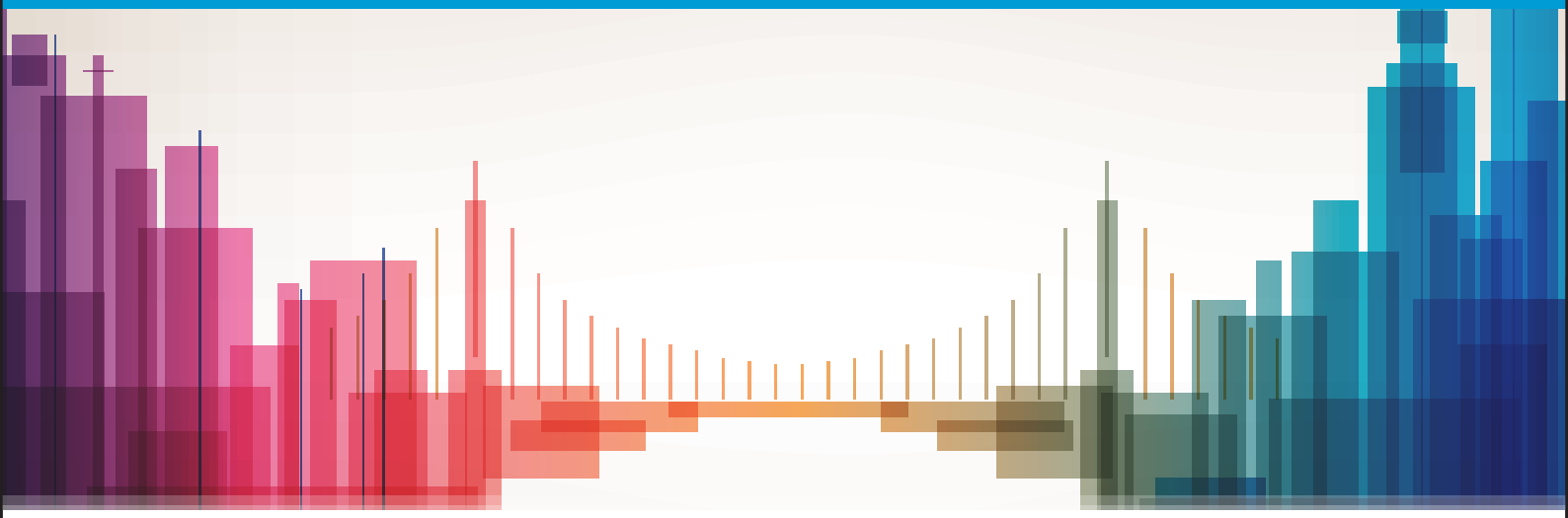
United 4 Smart Sustainable Cities

Compendium of survey results on integrated digital solutions for city platforms around the world



Convention on Biological Diversity

United Nations ECLAC

Food and Agriculture Organization of the United Nations

ITU

UNDP Empowered lives. Resilient nations.

United Nations Economic Commission for Africa

UNECE

UNESCO United Nations Educational, Scientific and Cultural Organization

UN environment programme

UNEP FINANCE INITIATIVE

United Nations Framework Convention on Climate Change

UN-HABITAT FOR A BETTER URBAN FUTURE

UNIDO

UN4 PARTNERSHIPS

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UN WOMEN

WORLD METEOROLOGICAL ORGANIZATION

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Foreword

This publication was developed within the framework of the United for Smart Sustainable Cities (U4SSC) initiative.

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The development of this deliverable was led and coordinated by Ramón Ferri (Smart City Officer of the València City Council, Spain) in collaboration with Cristina Bueti (ITU), Sahifa Imran (Consultant, ITU), Mythili Menon (ITU), Ángel Gómez, Javier Llavador, Natalia Palomar and Víctor Vicente (València Smart City Office members).

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Disclaimer

The opinions expressed in this publication are those of the authors and do not necessarily represent the views of their respective organizations or U4SSC members. In line with the U4SSC principles, this report does not promote the adoption and use of smart city technology. It advocates for policies encouraging responsible use of ICTs that contribute to the economic, environmental and social sustainability, as well as the advancement of the 2030 Agenda for Sustainable Development.

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Executive summary

The United for Smart Sustainable Cities (U4SSC) initiative is a global platform dedicated to supporting cities in becoming smarter and more sustainable. The U4SSC is coordinated by the International Telecommunication Union (ITU), the United Nations Economic Commission for Europe (UNECE) and the United Nations Human Settlement Programme (UN-Habitat), with the support of 14 other UN bodies.

Smart city platforms (SCP) are becoming new digital urban infrastructure that facilitate the implementation of smart city strategies to support new and additional city needs, while also assisting with the efforts of addressing targets contained in the Sustainable Development Goals (SDGs). Smart city platforms provide cities with a technological base to incorporate a multitude of elements that can enable a city's digital transformation to help achieve the city's internal objectives, facilitate informed decision-making by policy-makers and promote cost-efficient and effective city operations. It has served as the blueprint for evolution, supporting the transition from fragmented urban operations to integrated management with data as the main asset.

Illustrated by success stories, this document presents the experience of cities, communities and municipalities participating in the U4SSC initiative in developing their smart city strategies, the governance of smart projects, and the principal role of a smart city platform (or set of key components that constitute it) in contributing to improving the lives of their citizens.

The cities also described the technical-administrative and project management organizations that support their city's strategy, as well as their competencies. They defined their commitment to standards (in the procedural and technological aspects) and the use of ICTs in the management of U4SSC key performance indicators (KPIs). Finally, the smart sustainable cities described their relationship with their citizens, the innovation ecosystem and the networks they worked with for the design, sharing and replication of smart and sustainable city solutions.

The selection of the use-cases has been conducted to highlight the experiences and results from various cities across the globe, with the expectation that this will provide considerable value for others that are exploring the domain or planning the adoption of a city platform.

The following sections include the experience of the selected cities (across geographic regions) concerning their city platforms and other strategic aspects of interest. Additionally, the related compendium includes the complete documentation provided by each city that participated in the elicitation exercise for the development of this report.

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List of Abbreviations

ACC	Auric Command and Control Centre
ADIF	Administration of Railway Infrastructures
AENA	Spanish Airports and Area Navigation
AENOR	Spanish Association for Standardization
AP	Access Point
API	Application Programming Interface
BIM	Building Information Modelling
BMS	Building Management System
CBD	Central Business District
CCTV	Closed-Circuit Television
CCPA	California Consumer Privacy Act
CEF	Connect Europe Facility
CIM	Civil Information Modelling
CP	City Platform
DIN	German Institute of Standardization
EIP-SCC	European Innovation Partnership on Smart Cities and Communities
EMT	Municipal Transport Company
ETLs	Extract Transform Load
EU	European Union
GDPR	General Data Protection Regulation
GIS	Geographic Information System
GQOL	Global Quality of Life
H2M	Human to Machines
ICC	Integral Control Centre
iCP	Intelligent City Platform
ICTs	Information and communication technologies
ID	Digital Identity
IEC	International Electrotechnical Commission
IoT	Internet of Things
ISO	International Organization for Standardization
ITU	International Telecommunication Union
KPI	Key Performance Indicator
LED	Light Emitting Diodes
LPWAN	Low Power WAN
M2M	Machine to Machine
MIMO	Multiple-Input and Multiple-Output
PLC	Power-Line Communication

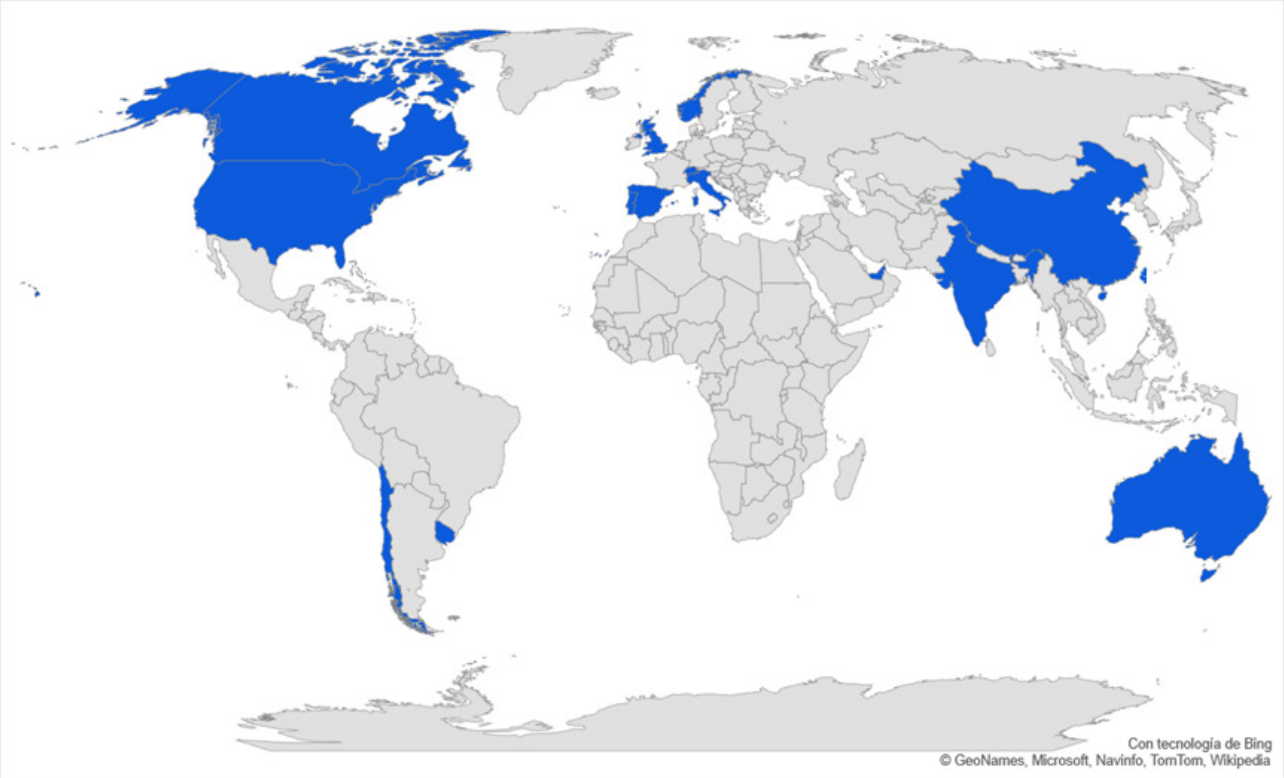
PPP	Public Private Partnership
ppb	Parts per billion
PRM	Person with Reduced Mobility
RCMS	Remote Control and Monitoring System
RECI	Spanish Smart City Network
ROI	Return on Investment
SCADA	Supervisory Control And Data Acquisition
SCP	Smart City Platform
SDGs	Sustainable Development Goals
SDO	Standards Developing Organization
SDP	Smart Dubai Platform
SME	Small and Medium-sized Enterprises
SNSP	Singapore's Smart Nation Sensor Platform
SSC	Smart Sustainable Cities
U4SSC	United for Smart Sustainable Cities
UAE	United Arab Emirates
UK	United Kingdom
UNE	Spanish Standardization Body
UNECE	United Nations Economic Commission for Europe
UDP	Urban Data Platform
US	United States
USA	United States America
WG1	Working Group 1

1 Introduction

This document serves as a compendium of the survey results provided by the representatives of the cities to lay the groundwork for the research and drafting of the report on Digital Solutions for Integrated City Management and use cases. The following sections contain the responses provided in the relevant template, within the remit of the U4SSC initiative.[1]

Figure 1 shows a geographical view (by country) of the cities participating in this survey.

Figure 1: List of countries with one or more city participants[2]



Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of ITU and of its secretariat concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

2 Bangalore (India)

2.1 City profile

Bangalore is a metropolitan city located in the state of Karnataka, India. The digital technologies infrastructure is leveraged towards the objective of job creation and enhanced employment generation.

Currently, ICT-based development is a priority of the city.

2.2 Strategic approach

Work on digital transformation is currently underway to create new sectors that will lead to the implementation of sustainable development.

Initiatives such as accessibility, inclusive development and digital financial inclusion utilizing digital technology solutions are being used to develop blockchain and payments application platforms.

2.3 Technological architecture of the urban platform

Inclusive development and sustainable solutions have enhanced employment generation with a focus on creating new Innovative ideologies and research-oriented sectoral areas. The efficiency of lower-cost applications in digital technologies has contributed to this transformation.

2.4 Set of operational IT solutions for integrated city management

Mobile applications used by the citizens in the city are already in place, thus enabling successful intervention in the areas of accessibility and inclusive development.

2.5 Governance

The impact management programme in implementing digital transformation has successfully created new jobs in the city.

2.6 Economic Sustainability

Fellowships, grants and investment facilitation opportunities have aided the implementation of the identified solutions.

2.7 Key Factors and Barriers to Implementation

Successful completion of digital technology-based product solutions.

2.8 Stakeholders' involvement

This includes public-private partnerships.

3 El Hierro island

3.1 City Profile

El Hierro is the southernmost and westernmost island of the Canary Islands, Spain, and has the highest density of volcanoes in the Canary Islands.

El Hierro comprises three municipalities: Valverde, La Frontera and El Pinar. Historically, its economy has been based on the primary sector as the main pillar and on an incipient tourism sector that, in recent years, has been linked to its sustainable development model.

This commitment to a sustainable development model led UNESCO to declare it a World Biosphere Reserve in 2000 and a World Geopark in 2015. The Sustainable Development Plan includes the *El Hierro, 100% RES* strategy and its objective is to introduce the use of renewable sources in all sectors where energy is required.

El Hierro is a first-rate island laboratory with palpable examples of sustainable development that can be replicated in other places on the planet and whose most obvious example is found in the operation of its hydraulic power plant. Based on wind and hydroelectric power, El Hierro has managed to become the first energy-isolated territory in the world to aspire to energy self-sufficiency through renewables. In August 2015, El Hierro's entire electricity demand was met with renewable resources.

The Island Councils (*Cabildos Insulares*) are institutions of the Autonomous Community of the Canary Islands. As organs of the government and the administration, they represent each of the seven islands in the Autonomous Community of the Canary Islands. According to the Statute of Autonomy of the Canary Islands, the *Cabildo Insular* of El Hierro is responsible for exercising its authority along with those that are transferred or delegated to *Cabildos*. This is in accordance with the development and execution of the agreements adopted by the Government of the Canary Islands and in line with the terms established by the laws of Parliament.[3]

3.2 Strategic approach.

The objective of transformation into a "Smart Island" is part of the global sustainability strategy that El Hierro has been following for the last 25 years.

This strategy seeks to reverse the difficulties faced by a remote and isolated territory (double insularity) with few economic resources and significant orographic difficulties by using a new approach to address the issues as well as seizing the opportunities arising from these singularities.

The strategy seeks to put natural resources at the service of the people, making the island self-sustainable from all points of view and promoting an economy that is in line with this strategy:

100 per cent energy-renewable and 100 per cent recyclable, while developing a strategy for sustainable mobility.

In addition, the Island has made an effort to enhance its rural character when adapting a tourism strategy that differs from the rest with a series of specific services and types of accommodation (e.g., rural houses, hiking and diving). The island is recognized worldwide for the quality of its seabed, and the *Cabildo* has promoted this value given the enormous economic potential it has for the island and its economy, promoting specialized tourism and a series of services to be developed to welcome new visitors.

In relation to volcanic events and the impact they have had on the island recently, it is necessary to consider managing the opportunity to generate added value and opportunities such as the scientific potential of El Hierro to host researchers and entrepreneurs in relation to these seismic and volcanological events. In this sense, the promotion of the Volcanological Interpretation Centre through which citizens and professionals can learn and deepen their insights acquires a special value.

The island has a rich natural heritage. The network of protected natural spaces (*Red de Espacios Naturales Protegidos*) of the Canary Islands in El Hierro collects the best vegetation samples of the islands. There are several species endemic to the island and there is a rich variety of habitats that are home to different threatened species such as the giant lizard of El Hierro. El Hierro was declared a "Biosphere Reserve" by UNESCO in January 2000 to preserve an invaluable natural, cultural and scenic heritage.

Additionally, El Hierro has been declared a Geopark by UNESCO. A Geopark is endowed with an important geological heritage due to its scientific value, rarity, or aesthetic or educational value, in addition to other natural and cultural heritage elements. For these reasons, a Geopark is considered a new model for socio-economic development in rural areas.

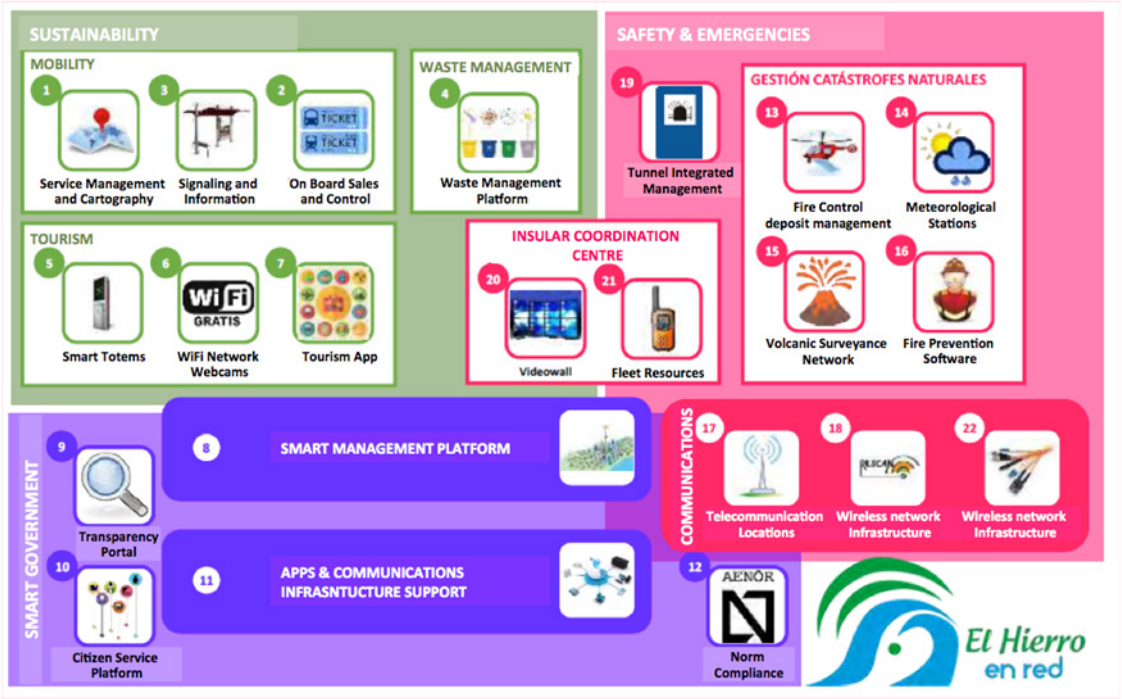
All these ideas are to be integrated under the umbrella of "Smart Island", enhancing the value of new communication and telecommunication technologies to improve the quality and perspective of life of its inhabitants and visitors.

The island's digital transformation is promoted through different initiatives and projects, among which the following stand out:

- *Hierro 100% Renovable* (Hierro 100 % Renewable), to make the island a self-sustaining place from an energy point of view.
- *Hierro 100% Reciclable* (Hierro 100 % Recyclable), promotes progress in waste management and recycling, as well as in environmental education.
- *Plan Director de Movilidad Sostenible* (Sustainable Mobility Master Plan), which seeks to reduce the emission of carbon dioxide, promote the use of public transport and define an integrated mobility system on the island.

- *Plan de Modernización del Cabildo de El Hierro* (Modernization Plan of the *Cabildo* of El Hierro), aimed at improving administrative management through the use of new technologies including the quality of public services, administrative simplification, electronic administration and open government.
- *El Hierro en Red* is the initiative that marks the driving force of El Hierro as a smart island, starting with the implementation of a smart management platform and ICT, and IoT actions in different areas: sustainability (mobility, waste management and tourism/economy), smart government (open-data portal and app with citizen services), and security and emergencies (prevention of natural catastrophes and emergencies in general).

Figure 2: El Hierro projects



These are some of the initiatives of the island institution to address and combat the impact and limitations that El Hierro has as a remote island region, based on innovation and sustainable development.

The smart platform consists of integrating the nucleus of the smart city, allowing it to have an integrated vision and management of information (consuming and generating the data of the different services), thus providing greater control over the processes and decision making. The platform is based on the UNE 178104: 2017 standard (UNE is the Spanish standardization body in ISO, IEC, CEN, CENELEC, ETSI, COPANT) following open, non-proprietary standards and standardized by international organizations and consortia.

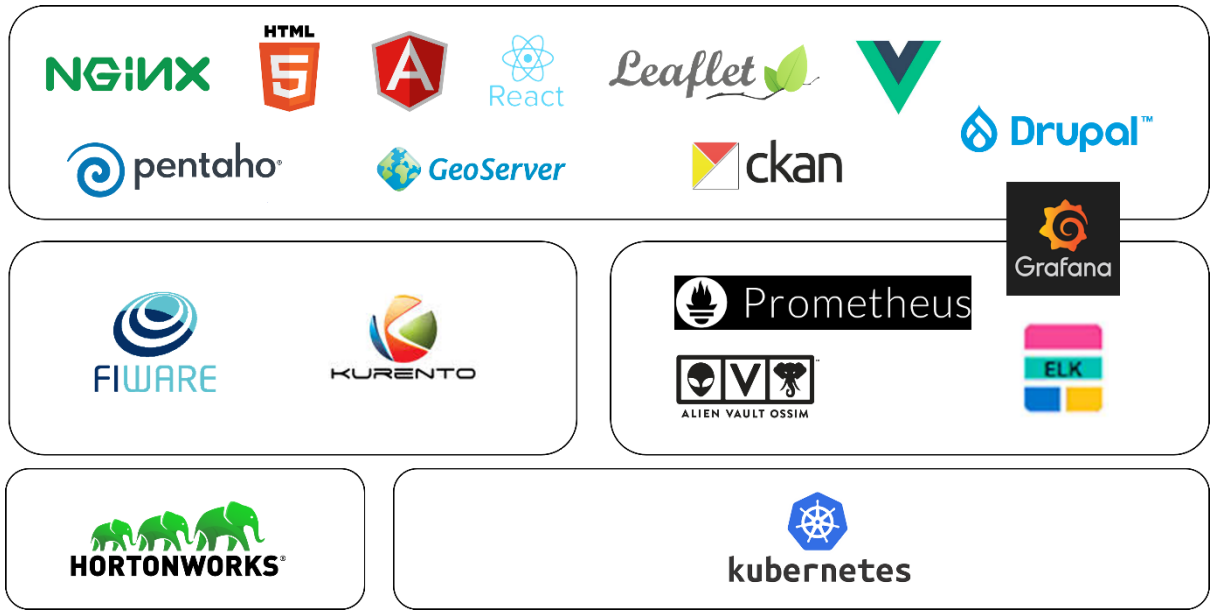
It incorporates a Dashboard that facilitates the operation of city indicators (KPI) coming from the different services and systems, for operational and strategic analysis and monitoring. The catalogue of indicators is also based on the standards of the main standardization bodies.

3.3 Technological architecture of the urban platform

The smart platform (IdomSmart) is based on three fundamental pillars:

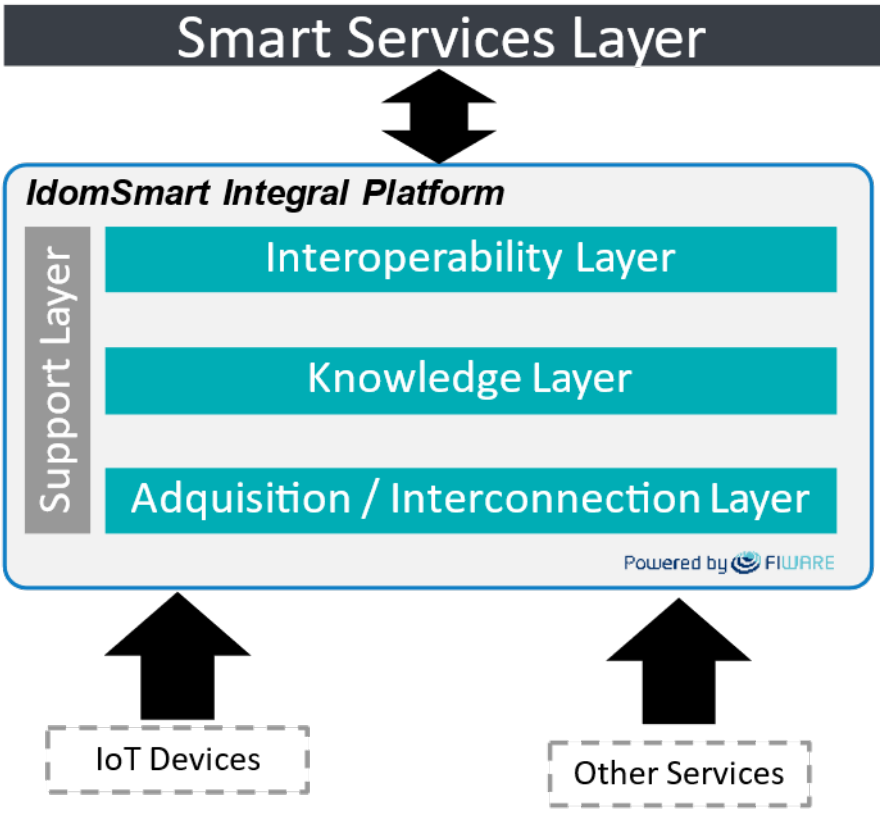
1. SMART IoT FIWARE: platform, promoted by the European Union for the development and global deployment of IoT applications.
2. Big Data HortonWorks: Big Data solution for processing data sets through computer clusters, developed and supported on Apache Hadoop.
3. BI Pentaho CE: business intelligence tool in its Community Edition format to generate the Scorecard, Indicators and Reports.

Figure 3: Technological architecture



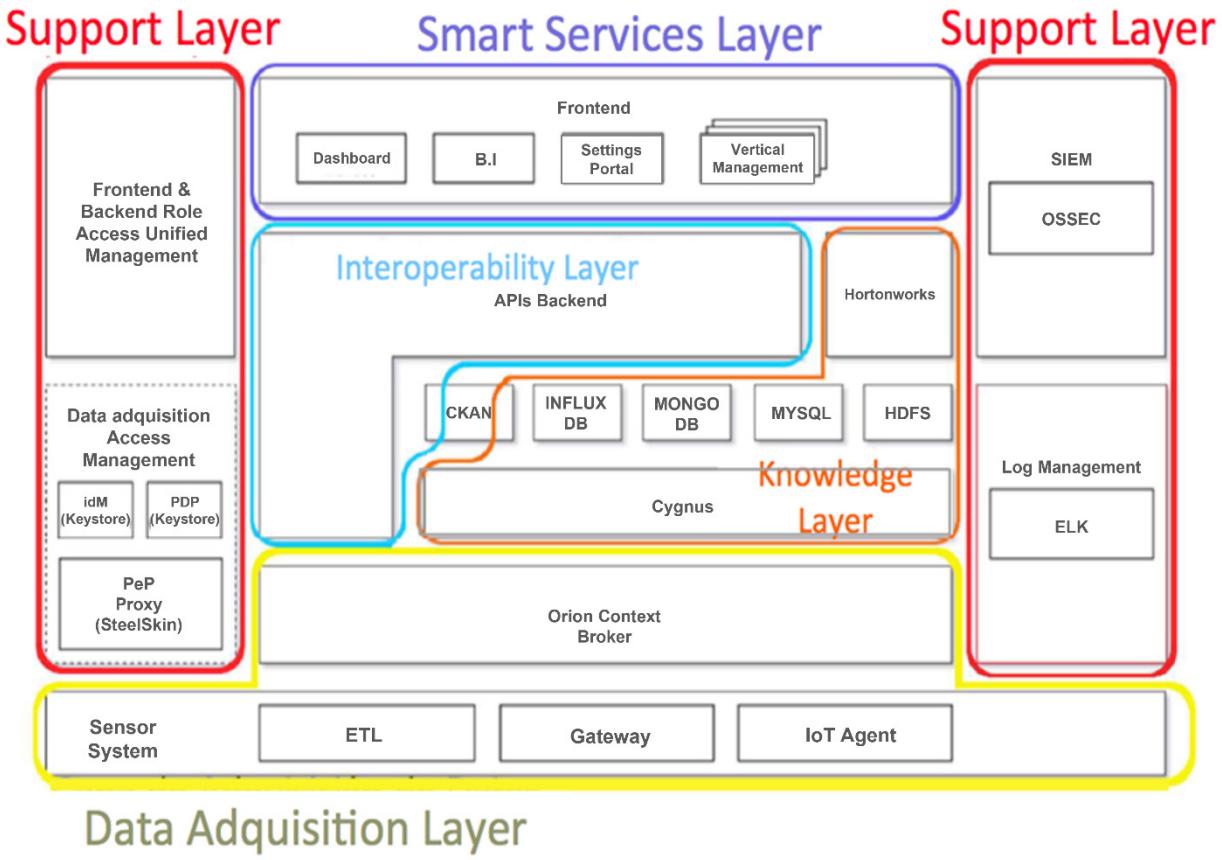
The smart platform is designed in accordance with the UNE 178104 standard, respecting the proposed layer model and using a solution based on the IoT FIWARE platform.

Figure 4: Platform architecture



The proposed architecture model is composed of independent modules focused on finding a solution to a specific problem.

Figure 5: Architecture model



The system is currently deployed on a set of virtualized physical servers. Kubernetes free software is used to achieve automation of the deployment, scaling and handling of the containers related to the smart platform to be installed.

Kubernetes separates developers from the hardware infrastructure that is being used, simplifying the management of software projects. Increasing resources is as simple as adding new nodes to the Kubernetes cluster (K8s), while developers only need to utilize a number of high-level APIs to deploy new developments, agnostic of the hardware in use.

Since developers do not have to think in terms of machines (virtual), applications can be deployed on the same shared machines, offering an advantage in the use of resources and cost savings (CAPEX or OPEX in cloud).

The platform has a Business Intelligence (BI) solution based on Pentaho CE software on which a series of improvements have been made.

For the monitoring of logs, a solution based on ELK has been implemented, ELK being the acronym for three free software projects:

1 Elasticsearch: a database engine optimized for searches for and analysis of data.

2 Logstash: a data-processing channel on the server side that ingests data from multiple sources simultaneously, transforms them and sends them to Elasticsearch.

3 Kibana: allows users to view data stored in Elasticsearch using tables and graphs.

This log monitoring tool is, in turn, integrated with a powerful event monitoring tool (OSSEC).

The database engines used are:

- Time series database (InfluxDB).
- Relational database (MySQL).
- NoSQL database (MongoDB).
- Distributed file system (HDFS).
- Open data management system (CKAN).

The platform has Big Data based on two frameworks, Apache HUE and Apache HIVE, a Hadoop tool. They offer an SQL-like or SQL-based query language.

The platform allows the exchange of data with other consumer entities – as occurs, for example, with information from volcanological stations, whose data are sent to the systems of entities in charge of analysing and exploiting their data.

In order to send data, the tool must have an API HTTP that can receive the data sent from the platform through the Context Broker.

Likewise, an open-data portal has also been developed, in which the information available on the platform about the different components is uploaded.

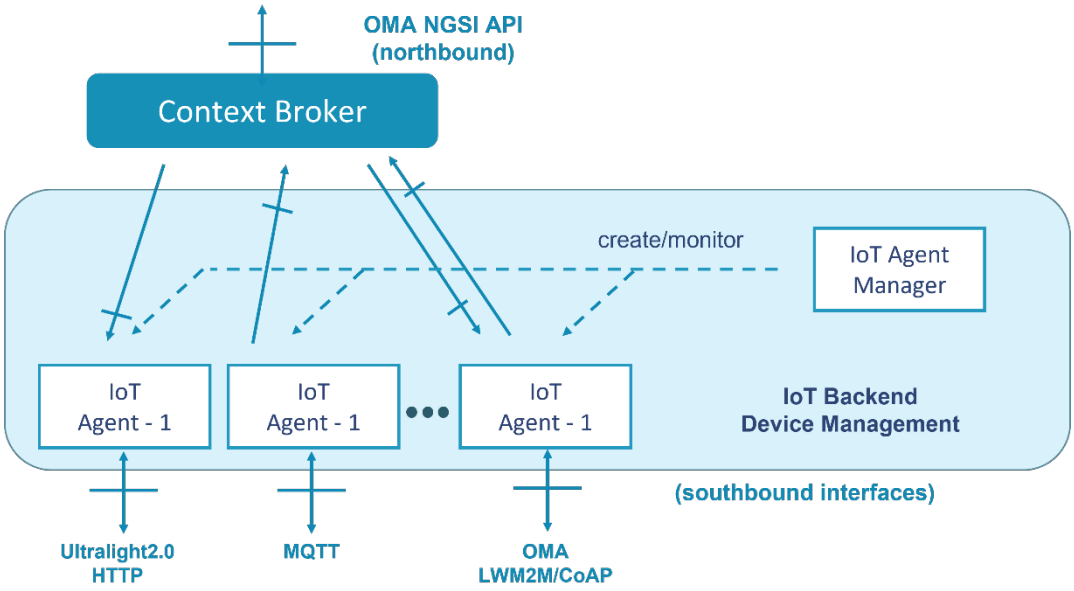
The IoT agents are in charge of receiving data from the devices/sensors and adapting them from the capture protocols to the consumption format by the Orion Context Broker. IoT agents, due to their southbound interface, are in charge of communicating directly with the different sensorization devices and performance, and by its north interface (northbound) with the API NGSI9 and NGSI10 through the Orion Context Broker. This modular architecture enables the implementation of different IoT agents that respond to a totally heterogeneous range of devices that use different communication protocols and transfer the information to a common language at the platform level based on standardized NGSI entities.

Each IoT agent provides the ability to interact with devices with a specific protocol. If a specific modelling – or "mapping" of attributes – is desired, it is necessary to provide the rules to apply, which may require the provision of the devices to establish a specific model associated with a

specific device. Currently, different types of agents for each of the IoT communication protocols and data models have been developed. Some examples of these implementations are:

- IoTAgent-JSON: an adapter between HTTP/MQTT messaging (using JSON) and NGSI.
- IoTAgent-LWM2M: an adapter between the Lightweight M2M protocol and NGSI.
- IoTAgent-UL: adapts communication between HTTP/MQTT messaging (using UltraLight 2.0) and NGSI.
- IoTAgent-LoRaWAN: manages the adaptation of communication between the LoRaWAN protocol and NGSI.

Figure 6: IoT communications



3.4 Set of operational IT solutions for integrated city management

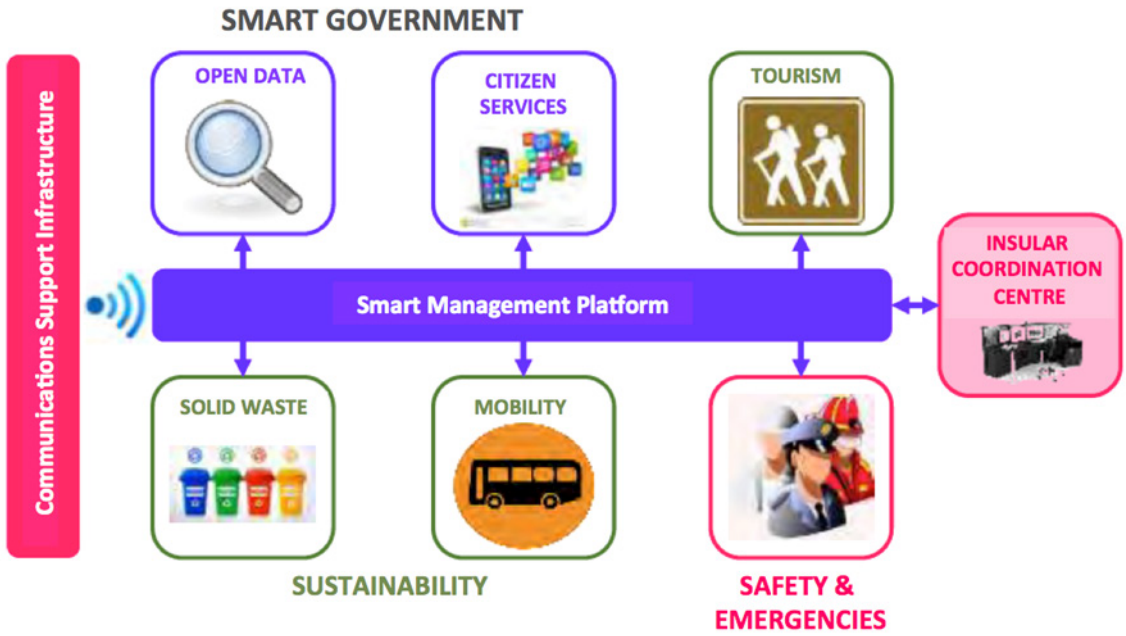
The *El Hierro En Red* initiative plants the seed of a smart island in the territory of El Hierro. Its components being put into operation constitute the base for building and implementing new services and components in the future, all on the smart platform that has been launched.

This initial initiative is focusing on three main axes:

- Sustainability: mobility (GIS, public transport management system on the island), Waste Management and Tourism/Economy (smart poles network, webcams, tourism mobile application).
- Smart Government: smart platform, open-data web portal, app.
- Security and Emergencies: prevention and action in case of natural catastrophes and emergencies in general. Management of water tanks for fire control, fire management software,

meteorological station network, volcanic surveillance network, communications improvements, infrastructure, and emergency network equipment (TETRA) and Integrated Tunnel Management.

Figure 7: Main axes of smart governance



The list of specific services or components into which the initiative is divided, is as follows:

- Component 1: Smart platform, BI And Dashboard

  Smart platform that collects information from all smart services, facilitates their management, makes it possible to have indicators and, therefore, to have information for decision making.

- Component 2: Geographical Information System (GIS)

  The GIS enables the query and operation of all the geographic information associated with the territory.

- Component 3: Transport Service Management

  System for the management of the public transport service on the island (buses or *guaguas*), which makes it possible for service managers and users to know the status of the service in real time, as well as billing management.

- Component 4: Smart Poles Network

  Deployment of smart poles in the island's trails network to provide information to users and as a communication mechanism in case of emergencies.

- Component 5: Waste management

  Definition of an intelligent waste-management model on the island.

- Component 6: Weather stations network

  Deployment of meteorological stations, which help in the detection of alerts and prevention of emergencies on the island, related mainly to the risk of fires.

- Component 7: Fire-prevention software

  Software for determining the fire risk index, based on meteorological parameters and factors which help to prevent them.

- Component 8: Management of water tanks for fire control

  Sensorization of water tanks on the island, which provides information on the filling status of the tanks for use in emergency situations due to fires.

- Component 9: Volcanic surveillance network

  Deployment of volcanological stations of different types to get information about volcanic and seismological activity on the island and to assess risks of this nature.

- Component 10: Integrated tunnel management (communication coverage improvement, SOS poles, video cameras and information panels)

  Improvement of communications and security equipment and surveillance of tunnels on the island for the prevention, or action in emergencies.

- Component 11: Infrastructure improvement of wireless networks (TETRA and Transport Network) (TETRA stations and radio links)

  Improvement and expansion of the TETRA radio network for security and emergencies on the island.

- Component 12: TETRA equipment for fleets (mobile and portable terminals)
- Component 13: Improvement of the network of access points: wind/EOLIC generator and webcams

  Deployment of webcams in the main tourist spots the island allow visual verification of their status (e.g., meteorology, occupation).

- Component 14: Infrastructure improvement of telecommunication sites (security cameras)
- Component 15: Fibre-optic link (CECOPIN – *CABILDO* main building) (≈600 m)

  Improvement of the internal network of the *Cabildo* for the transmission of information between the central infrastructure and the headquarters of the Insular Incident Coordination Centre (CECOPIN).

- Component 16: Videowalls in the insular coordination centre
- Component 17: Central infrastructure (CPD) (rack, servers, switches, cabinet, NVR recorder) to house the smart platform, databases and software associated with all components.
- Component 18: Open-data Portal

Construction of an open-data portal that allows the publication of island and municipal data for access and re-use by citizens and companies.

- Component 19: Web portal

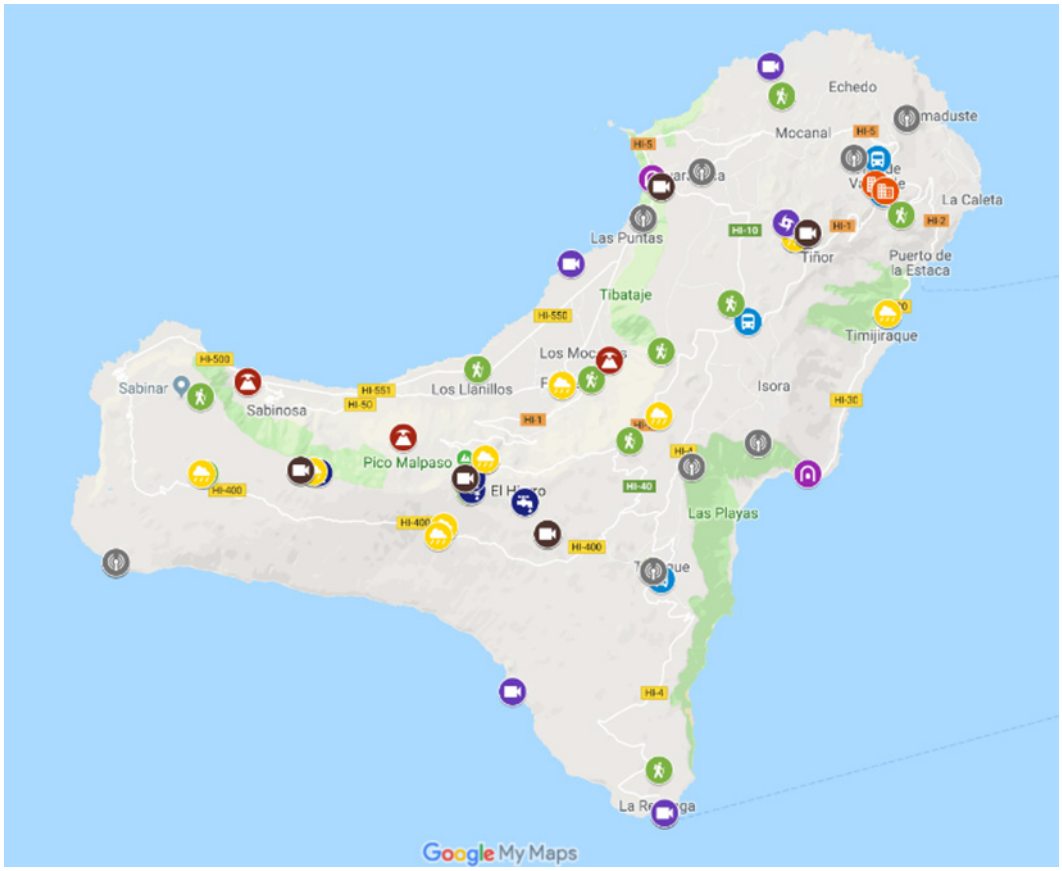
  Construction of a new web portal that brings together all the information about citizen services in all areas of society.

- Component 20: Mobile application (Transport, tourism and citizen services)

  Development of a mobile app that allows citizens to access three main services: public transport on the island, tourist information, and information and procedures for public services.

The following map reflects the geographical points where the different components are located on the island:

Figure 8: Map where the different components are located[4]



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The different areas of the *Cabildo de El Hierro* are responsible of the management of the platform and services.

The databases are centralized, and the entire software infrastructure is deployed on physical servers located on the *Cabildo's* State Contracting Platform (CPD). Any other entity can access the information through the open-data portal, the web portal, the app or the public GIS viewer. Special care has been taken to define security policies for communications and for the management of, and access to, information.

Project management methodologies are used for the deployment of services and for the operation, covering all phases and aspects including: analysis, design, development, deployment, tests, training, maintenance, document management and security management. All of them follow the applicable regulations and standards in the different areas, including relations with smart cities.

The components and solutions follow the appropriate technical standards for interoperability generated by the Technical Committee for Standardization AEN/CTN-178 Smart Cities.

The solutions deployed ensure possible subsequent developments and possible new integration with other systems.

The information update frequency can be defined for each component, which varies according to the need.

3.5 Governance

The digital transformation in the territory, under the management of the *Cabildo de El Hierro*, is being structured mainly in accordance with the Modernization Plan (2018–2021) and the smart island initiative of *El Hierro en Red* currently being implemented (October 2019–October 2021).

These actions define the responsibilities of the organization to manage the digital transformation of smart city projects. The required training for the operation and use of the solutions is included in the projects.

The following are the highlights of the smart island project:

- It is managed by the Modernization and New Technologies Department.
- The actions that are undertaken are formally reported to the Governing Council, which represents the political powers of the territory.
- The work is coordinated with each different area involved (i.e., Administrative Organization, Human Resources, Tourism, Transport, Environment, Waste, Security and Emergencies, Press, and Territory) from the analysis phase to execution/operation.

The projects also involve coordination and collaboration with the rest of the Local Administrations (city councils) of the island, as beneficiaries of the services and as potential generators of new services that can be implemented on the platform.

Likewise, different collaboration agreements have been concluded with the public and private sectors for the adequate and coordinated deployment of infrastructure and services, and for the operation and analysis of information in order to ensure maximum efficiency and competence. Collaboration partners include:

- RESCAN (Canary Islands Safety and Emergency Network of the Government of the Canary Islands) for the management of the infrastructure deployed in relation to the TETRA network (Safety and Emergency Network) and the integration into its network.
- IGN (*Instituto Geográfico Nacional* – National Geographic Institute) and INVOLCAN (*Instituto Volcanológico de Canarias* – Volcanological Institute of the Canary Islands) for data processing from volcanological stations.
- Port Authorities (State ports and Canary Islands Ports).
- Cooperative Society for the Transport of Travellers of the Island of El Hierro (TransHierro).
- Telecommunication operators.

It is also necessary to explain that the *El Hierro En Red* initiative is being executed within a collaboration agreement between the *Cabildo de El Hierro* and *Red.es* (belonging to the current Ministry of Economic Affairs and Digital Transformation) for the development of the "Smart Cities and Communities" initiative, financed with community funds (Operational Programme ERDF 2014-2020).

As mentioned above, the project is now in its execution phase; consequently, one of the tasks is to inform citizens about the services and technologies deployed, mainly through the web, the mobile application and open-data portals.

The Cabildo public bids include requirements for integration with the tools that are being implemented.

3.6 Economic sustainability

As previously explained, the *El Hierro En Red* initiative being executed is based on a collaboration agreement between the *Cabildo de El Hierro* and *Red.es* and financed with community funds in the 2014–2020 Operational Programme ERDF.

For its Smart Island strategy, the *Cabildo de El Hierro* assigned in its annual budgets a specific economic item for this purpose, in addition to the budget for other digital or technological transformation projects such as Electronic Administration, corporate services or communications.

With an eye on sustainability and future evolution, the *Cabildo* is also working on obtaining regional financing (FDCAN) and new lines of European and/or national funding.

The framework of work and collaboration in FECAM (Canary Federation of Municipalities) and FECAI (Canary Islands Federation) also has great value, allowing local entities to establish a coordinated and organized framework in the territory, which is more sustainable and offers possible economies of scale.

Communication and contact with the private sector is also constant, a potential generator of services following the path that the *Cabildo de El Hierro* is opening with its projects.

In short, the involvement of the different economic, social and political agents, added to the *Cabildo's* commitment, guarantee the continuity of a smart island strategy in El Hierro.

3.7 Key factors and barriers to implementation

The success factors include:

- Involvement and commitment of the different economic, social and political agents.
- External financing for the development of projects.
- Coordination and agreements between administrations and entities for the execution and systems operation.
- Good management and orderly work: Project methodology, planning, coordination, monitoring, document generation, etc.
- Information and its dissemination (internally and to the public).
- Training to operate and use the services.

Barriers found:

- Execution difficulties in a remote territory (double insularity). Project execution costs, logistics and execution times.
- Few internal human resources for management and operation.
- Administrative procedures and times of public procedures (in the Public Administrations) associated with agreements between Administrations or the necessary tenders for the project execution.
- Contingencies derived from the situation around COVID-19.

In July 2015, *Red.es* launched public grants for Smart Islands, for local Public Administrations in the Canary Islands and Balearic Islands. The initiative *El Hierro en Red*, presented by the *Cabildo of*

El Hierro, was selected, with a budget of EUR 3 852 670, which is 100 per cent contributed by the Ministry, through Red.es, with co-financing from the European Regional Development Fund (ERDF).

Since then, *Red.es* has tendered the main project actions in the initiative, which includes the Smart Platform. The winner of the tender is the company IDOM CONSULTING, ENGINEERING, ARCHITECTURE, whose smart platform has been described above.

Compliance with all current regulations is a commitment to carry out the actions.

Data protection is given special attention, applying the requirements established by the Spanish Data Protection Agency and the regulations (LOPD, Organic Law on Data Protection).

On the other hand, all actions entail compliance with specific security policies that cover the following aspects:

- Authentication and authorization.
- Security in communications and securing of all the elements deployed in the different components, especially the sensorization layer, enables mechanisms that guarantee data security, to prevent unauthorized access to devices. For example encryption, authentication of communications between devices, defence mechanism against cyberattacks.
- System monitoring and integrity.
- Centralized log registry.
- Backup, restoring and duplication of data.

The security policies revolve around the axes of confidentiality, integrity, authenticity, traceability and availability:

- Confidentiality: regarding disclosure to unauthorized persons or those who do not need to have the information.
- Integrity: responding to the consequences of its modification by someone who is not authorized to modify the information.
- Authenticity: responding to the consequences of the fact that the information they manage or contain was not authentic.
- Traceability: responding to the consequences of not being able to trace after the fact who has accessed or modified certain information.
- Availability: responding to the situation when an authorized person is not being able to access the information when they need it.

The developments also apply to the requirements established in the National Security Scheme (ENS) and the National Interoperability Scheme (ENI).

3.8 Stakeholders' involvement

As mentioned previously, one of the success factors of the projects is the commitment and involvement of the economic, social and political agents in the territory. Along with the general public, they will be the direct beneficiaries of the projects.

The *El Hierro en Red* initiative is part of the strategy on sustainability, pursuing objectives and benefits such as:

- Greater social and territorial cohesion. Reduction of the digital divide and greater ease of access to the use and development of technologies.
- More agile and efficient quality public services, providing indicators to evaluate and improve the efficiency of public services on the island.
- More transparent, accessible and efficient administration.
- Promote other strategic sustainable island projects.
- Connected island, breaking traditional geographical barriers.
- Providing enhanced value to island identity and heritage through innovative digital platforms.
- Better management of services in all areas with this initiative:
    - Security and emergency management in ordinary situations and in case of natural catastrophes.
    - Services of the tourism sector, as an essential activity in the economic development of the island.
    - Mobility and transportation on the island.
    - Waste management.
- Information re-use by all agents.
- Promoting entrepreneurship and local/island economic development through the best infrastructures and technological services.

As was explained in the Governance section, the projects are carried out in coordination with the rest of the local administrations (city councils) of the island. Different public collaboration agreements and private contracts have been established for a coordinated deployment of infrastructure and services, and for its operation and information analysis in order to achieve maximum efficiency and utility. Some collaborating entities are:

- RESCAN (Canary Islands Safety and Emergency Network of the Government of the Canary Islands) for management of the infrastructure deployed in relation to the TETRA network (Safety and Emergency Network) and integration into its network.

- IGN (*Instituto Geográfico Nacional* – National Geographic Institute) and INVOLCAN (*Instituto Volcanológico de Canarias* – Volcanological Institute of the Canary Islands) for data processing from volcanological stations.
- Port Authorities (State ports and Canary Islands ports).
- Cooperative Society for the Transport of Travellers of the Island of El Hierro (TransHierro).
- Telecommunications operators.

Additionally, the *Cabildo of El Hierro* has multiple frameworks of collaboration and work in the technological environment such as FECAI (Canary Islands Federation), FECAM (Canary Islands Federation of Municipalities), General Foundation of the University of La Laguna, Technological Institute of the Canary Islands and the Inter-administrative Network of Open Government.

The appropriate clauses for the management of information, confidentiality and the treatment of data are established in the different public agreements and private contracts.

The above is a summary of how different Canary Islands Public Administrations collaborate and work together in the smart city projects in their territories.

4 Las Condes, MR (Metropolitan Region), Santiago de Chile

4.1 Strategic approach.

In Chile, more than 100 000 public lighting fixtures have been replaced in the last two years by the Chilean Energy Efficiency Agency (AChEE) within the framework of the massive replacement of 200 000 units promoted by the Ministry of Energy. The incorporation of new technologies such as the installation of LED and intelligent lighting systems, is changing the face of the energy sector in this area.

In the first stage, Las Condes contemplated the replacement of 22 000 lights, each with a motion sensor, out of the 42 000 that exist in the commune. More than 2 000 additional sensors with a multiplicity of functions that connect to the luminaires were also installed. The sensors also measure congestion by detecting the number of vehicles on the road and the speed at which they are moving. Added to this are another 400 sensors that measure air quality, 300 that control automatic irrigation based on climatic data, and 300 more sensors that measure noise levels in certain sectors of the commune. All these data are available online for the community.

The criteria established for an Open Smart City programme considered the following innovations:

- Collect information from the city, citizens and companies, complying with pertinent privacy requirements .

- Distribute the information so that it can be processed by those responsible for the different municipal services such as waste management, environmental safety, mobility parking, traffic and public transport, emergency management and public order and smart meters for water, gas and electricity.
- Analyse the information according to established criteria.
- Make decisions by returning the refined information to the systems in charge of executing the different actions.

  Exposing data and capabilities to developers to facilitate the creation of an ecosystem of applications on the platform, which creates additional value for the citizen.

4.2 Technological architecture of the urban platform

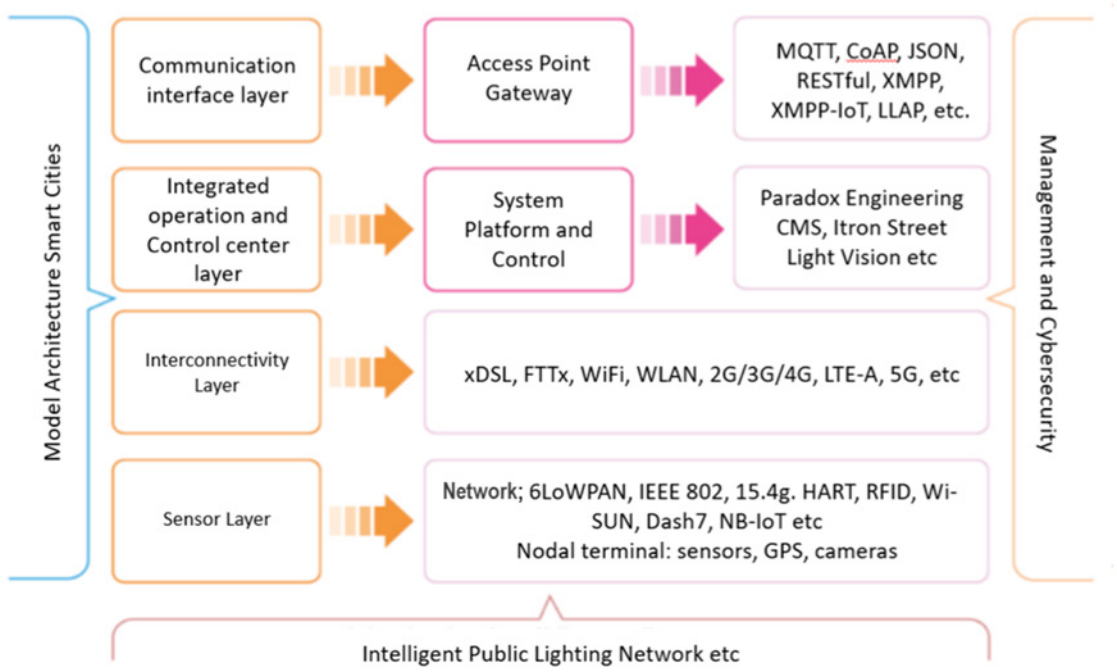
Figure 9 presents a proposal for an Open Smart City Enabling Infrastructure from the Smart Public Lighting Network to be applied in Chile showing an architecture corresponding to the information and communication technology realm of an Open and Sustainable Smart City, emphasizing the Smart Public Lighting Network (RAPI). The proposed architecture consists of the following layers: Intelligent Public Lighting Network (RAPI), layer of sensors and connected devices, interconnectivity layer, layer of Integrated Operation and Control Centres, as well as an application layer and communication interfaces.

A detailed description can be seen in the document "Model Master Plan for the Development of Enabling Infrastructure of an Open Smart City". ACTI-CORFO, September 2020.[5]

The technology to implement the technological architecture of an open smart city must be modular and expandable with widely adopted open standards, which can be combined with other platforms and connected with the population through user-friendly applications. Municipalities and cities can benefit from an Internet of Things (IoT) connectivity infrastructure that enables the development of smart solutions in a ubiquitous way.

The main requirements to implement the technological options for a low-frequency communications infrastructure for IoT should include open systems with low power consumption that operate in the low-frequency bands (less than 1 GHz) and which make use of open IPv6 communications protocols.

Figure 9: Architectural model proposed for an Intelligent Public Lighting Network (RAPI) from the point of view of communications



4.3 Governance

In the development of technological solutions and digital services for the construction of an open smart city in the municipalities and cities of Chile, it is necessary to build an adequate legal framework, establish short- and long-term policies and structures that allow for the proper governance of these smart territories (cities and municipalities), as well as public programmes and public-private alliances that financially support their implementation. The existing legal framework in the country is of great importance for the development of open smart city projects.

4.4 Economic sustainability

A major barrier to the implementation of these projects is financial sustainability. Tax revenues are not always adequate, especially in municipalities. It is not easy to sustain the costs of the proposed solutions, especially when required to implement infrastructure for cabling, poles, lights, sensors, cameras, computers, management systems and mobile applications, as well as the creation of an Integrated Operation and Control Centre.

In Chile, the Corfo initiative for the development of the Enabling Infrastructure of Open Smart Cities is based on the use of the ubiquitous networks of public lighting systems. This development requires significant investment to develop open smart city projects.

4.5 Key factors and barriers to implementation

In Chile, there is great diversity among municipalities in terms of their available financial resources and their capacity to leverage resources for this type of initiative. Some have made an effort to digitize the services of their communes to improve the quality of life of their neighbours (Las Condes, La Reina, Vitacura, Santiago, among others), but it is still insufficient to imagine an intelligent metropolitan territory. Among the major obstacles to moving in this direction are the alternatives for the financing of investments such as fibre-optic backbones, sensors, cameras, smart lights, computers, software and the Integrated Operation and Control Centre. Currently, there are some financing alternatives.[6] However, these are still very limited for municipalities.

4.6 Stakeholders' involvement

In a preliminary study carried out by the Innovation Club (2019) in Chile on the impacts of business models in future cities, business opportunities were found in the following prioritized areas: sustainability and environmental efficiency, citizen involvement and entrepreneurship in co-creation, and digital transformation and services. It is, therefore, necessary to create a technological directory that provides examples of governance for the development of open smart cities in metropolitan regions in which the regional government, ministries, municipalities, trade unions of technology providers, as well as academia all participate. These should address innovation in terms of new digital services such as business models, and the organization and coordination of the digital transformation of territories. The development of content for Open Smart Cities is still incipient in Chile, and while these barriers must be overcome, they do represent a great challenge for the development of smart cities and/or territories in Chile.

4.7 Other information of interest

Future trends

Here are some policy ideas that encourage the creation of open smart territories at the national level:

- Smart infrastructure.
- Communication and sensorization networks.
- Public-private partnerships.
- Digital equality.
- Innovation.

The cities of the future are being built today. Chile has the means to rise to this challenge successfully if it incorporates collaborative work and the use of technology as a necessary means for the development of safer, more productive cities.

5 Logroño

5.1 City profile

Logroño is a modern city, which is pleasant for its inhabitants and visitors alike. It is the regional capital of La Rioja with 151 021 inhabitants. Located in the north of Spain, it is a meeting and reference point at a crossroads. It is famous for the Camino de Santiago, which has attracted intrepid walkers from distant countries to this city and they, in turn, have enriched the city's cultural heritage.

Logroño is a quiet city on the river Ebro which invites one to stroll and relax along its banks. The city is currently experiencing a notable change compared to recent years. It is providing new services and infrastructure that give it greater appeal and a new standpoint to make it a benchmark and meeting ground among the cities around it.

Logroño is a stately wine city with a heart of tree-lined squares, narrow streets and hidden corners. It has a rich culture of wine and gastronomy along with the Camino de Santiago and the old town, which embodies the character of the first commercial city of Spain. Local festivals such as those of San Mateo in the month of September, and its glitzy shop windows exemplify a city that combines ancient traditions and customs with the modernity and dynamism of modern times.

Logroño is a city rich in history and heritage that have been preserved since the Middle Ages. Its dimensions invite a stroll and the leisurely enjoyment of its significant enclaves: the Paseo de El Espolón and the Cathedral of Santa María de La Redonda; the convent of La Merced, current seat of the regional Parliament; the characteristic Calle Portales, the church of Santiago El Real or that of Santa María de Palacio are some examples of interest that cannot be missed.

The Camino de Santiago made this one of the most important towns on the route, leaving an interesting monumental complex closely linked to the traditional passage of pilgrims.

Rioja vineyards contribute to some of the specialties that make up the recognized Riojan culinary tradition and reputation. Gastronomy is at the soul of an amazing array of tapas bars that offer bite-sized *pinchos* and local red wine accompanied by attractive cultural offerings and good hotel accommodation, with recommendations to drop by one of the many wineries that can be visited by appointment.

5.2 Strategic approach

In 2014, the City Council of Logroño made a strong commitment to using ICT intensively in municipal management. It aimed to provide continuity to different existing projects and initiatives, completing and expanding plans to build infrastructure and the communications network along with an integrated management platform as an instrument to rationalize government decisions and actions to provide effective, efficient and sustainable municipal services.

This resulted in the "Smart Logroño" project, a set of strategies, projects and actions that promote change in the city's governance model to turn Logroño into a smart city. The model is based on the integral management of municipal services that provides integrated and simultaneous solutions as compared to the exclusive and individual model that is currently in use, which tends to diversify technical and human resources and has a poor capacity to share information.

The new governance model focuses on the citizen as the final objective and driving agent of this transformation. It aims to improve their quality of life, improve relations with the administration, make more efficient use of available resources and create new economic activities that promote job creation and entrepreneurship.

This change in the management model requires advanced technological aids to build a common base of infrastructure and services to capture, standardize, store, share and analyse the large volumes of information required to facilitate appropriate management and strategic decision making, while promoting transparency and citizen participation.

Smart Logroño provides the city with a governance model that includes organizational structure, digital transformation operations and municipal services management. This constitutes an essential technological base to support single teleoperation and a common repository of services and standardized information that enable the subsequent integration of all municipal services. This is also in line with national-level ICT strategic plans such as the Spanish Strategy for Science and Technology and Innovation, and the National Plan for Smart Cities of the Digital Agenda for Spain. At the local level, too, it is in accordance with the Strategic Plan of La Rioja 2020, and the Agenda Digital de la Rioja and collaboration with AERTIC (Innovative Business Group of the ICT sector of La Rioja), as well as with the Municipal Plan for the implementation of Electronic Administration and the Master Plan for the integration of Vertical Services.

At an organizational level, the Smart Logroño project is structured around:

- The Smart Logroño Development Commission (CDSL), which is responsible for providing strategic direction and comprises a multidisciplinary team of people from different areas of municipal management.
- The Project Management Office (OGP), which is responsible for the execution of the project and is made up of municipal technicians and support personnel from the companies that were awarded UTE joint venture status as a temporary business alliance.

Prior to the overall conception of the project, the City Council of Logroño carried out different smart projects, which eventually led to the adaptation, in 2016, of communication infrastructure and contracts that mark the beginning of the "Smart Logroño" concept:

- Contract for the integrated urban services platform
- CON21 2016/0053 – Procurement for the public services management platform, Smart Logroño.

- Procurement for the Smart Building CON21 2016/0112 – Acquisition of equipment for the Smart Logroño Control Centre

The Smart Logroño Platform includes:

1) Installation of the ICT infrastructure to complete the deployment strategy to provide services to the Smart Logroño Platform and the Integral Control Centre (CCI).
2) Start-up and subsequent maintenance of the city's Comprehensive Management Platform that include:

    a) A core platform with basic and transversal modules for city intelligence; data capture and standardization; device management; analytical and georeferenced data management; preparation of maps, reports, indicators and executive dashboards for the management of services and global for the city government; surveillance and active listening into social networks; and availability of APIs for integration and interoperability with systems.

    b) The addition of common functionalities and applications to the vertical services to be integrated to facilitate communication with the public from the services rendered by the Integral Control Centre such as the management of systems for notices and incidents, care, complaints and suggestions, as well as the condition of public roads.

    c) Smart city portal for relations with citizens for access to contents of the Smart Logroño Platform and an open-data portal of the City Council of Logroño.

    d) Development and execution of a pilot project to verify the characteristics, functionalities and capacities of the platform.

3) Providing support to daily operations and the evolution of the Integrated Management Platform of the city. This includes consulting, development and implementation of projects to integrate vertical services in municipal systems.

In order to travel this path, Logroño has opted to participate and collaborate with city networks, and to adapt to the national and international norms and standards recommended by the United for Smart Sustainable Cities (U4SSC) initiative to which it has contributed:

- Spanish Network of Smart Cities (RECI): held the Vice-Presidency of RECI in the previous corporation and the Presidency in the current one, and is the coordinator of the Working Group.
- Member, Red Impulso , the innovation network in cities.
- United for Smart and Sustainable Cities (U4SSC)): participated in various thematic groups.
- Member, Open Agile on Smart Cities .

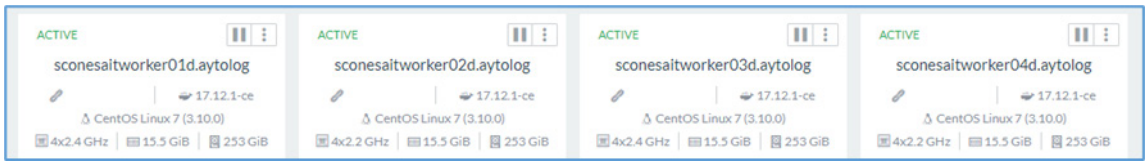
5.3 Technological architecture of the urban platform

The Smart Logroño Platform is based on the Onesait Platform of Indra's Minsait company[7], which provides the flexibility for developers to build their own solutions in a solid and agile way using open technologies. Its source is a flexible architecture and an innovative approach, which covers the entire life cycle of information from ingestion to visualization through processing and analysis. It offers a unified web console for the development and operation profiles of the solutions.

Servers

In the City Council of Logroño the platform is deployed in two environments with four machines each, which contain the different modules in an organized way so as not to saturate the servers.

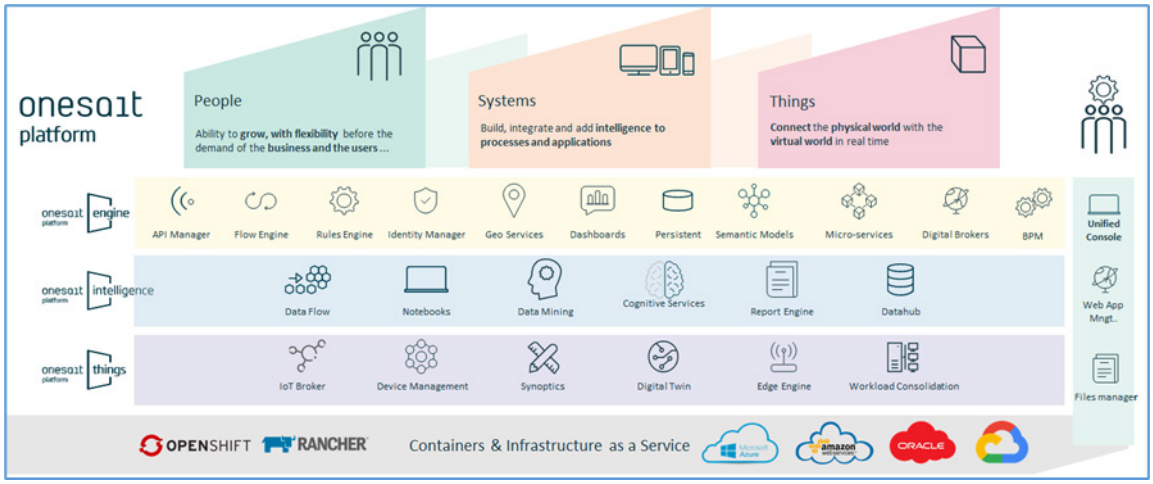
Figure 10: Servers



The modules are containerized and managed from a RANCHER module that allows them to be managed individually and can continue with the functionality of the platform even if a module fails.

Modules

Figure 11: Platform modules



Onesait Platform Engine Modules

API Manager:

Technologies: Spring boot, Swagger and Gravitee.

The API Manager enables apifying Swagger external APIs, flows and ontologies. It includes an API Portal and exposes these APIs via the Open API. There are two versions: the base one built by Spring Cloud and the advanced one on the Open Source Gravitee API Manager for scenarios in which specific policies are needed to control throttling, security, processing, etc.

Flow engine:

Technologies: Node-red.

The Flow Engine allows the user to visually model business logics through components that come together to solve that logic. This component runs on a multitenant, Node-red environment (like Watson IoT) and, among other things, facilitates publishing APIs, external consumer services and communicating with devices.

Rules Engine:

Technology: Drools.

The Rules Engine allows building business rules within the web console of the platform. This component is based on Drools and allows the user to define rules in DSLS and DRL. These rules can be triggered upon the arrival of Information to the platform, or be invoked by the API and isolated by the user.

Identity Manager:

Technology: Spring boot and oauth2.

The platform offers an Identity Manager that secures access to its APIs via OAuth2. In addition, it allows the creation of Realms for verticals to define their Security models visually. It offers SSO capabilities, integration with LDAP, Active Directory and Encryption. It also offers a base version on Spring Cloud Security and advanced on CAS.

Geospatial:

Technology: cesium.

The platform offers GIS capabilities in various fields, from the storage of Geographic Information on GeoJSON and geographic queries, to the visual and unscheduled creation of GIS Viewers on Cesium technology, and GI analytics.

Dashboards:

Technology: angular and vuejs.

This module allows the user to visually build complete dashboards that can exploit all the information managed by the platform. Gadgets that have already been created are offered, along with the possibility of incorporating new ones on any Javascript library (such as eCharts), supporting drill-down, security, parameterization and internationalization.

Persistence:

Technology: MongoDB, Elasticsearch, Mysql.

Through the concept of ontology, this module isolates the rest of the components from the underlying repository. The module offers a repository-independent unified SQL interface. Technologies such as MongoDB and Elasticsearch, Kudu and relational databases such as Oracle, Sql Server, Mysql and Postgresql are supported.

Semantics:

Within the data-centric approach of the platform, it allows managing semantics in a unified way adapting the appropriate semantic model according to the selected data model. Semantics, based on JSON as an interchange format, also supports JSON-LD for linked data scenarios.

Microservices:

Full support is provided for the creation and management of microservices from the web console, allowing the generation of the code, execution with the CI tool, compilation and generation of images and deployment in the CaaS infrastructure of the platform from a selection of microservices.

Digital broker:

It allows systems, devices, APPS, etc. to communicate with the platform through the most appropriate protocol depending on the scenario. It supports communication through protocols such as REST, MQTT, WebSockets and Kafka, as well as the incorporation of others. It offers Client APIs for different languages to simplify communication.

Onesait Platform Intelligence modules

DataFlow

Technology: streamsets.

This module allows the user to visually configure ingest flows between sources and destinations, so facilitating complex processing flows in high-concurrency environments. This component is used to integrate the platform with systems that cannot adapt to standard communication mechanisms. The implementation is based on Streamsets, and more than 100 standard connectors are offered in addition to the ones on the platform.

Notebooks

Technology: Python, Spark, R, SQL, Tensorflow.

This tool enables data scientists to exploit, visualize and create models and algorithms on the Information managed by the platform with the languages used in this area, including Python, Spark, R, SQL and Tensorflow, and all within a centralized and secure web environment. This component is based on Apache Zeppelin on which a platform interpreter has been developed that allows access to ontologies in a very simple way. Tools are provided for importing notebooks from Jupyter.

DataMining Tool Guides

This component allows business users to interactively and visually create exploratory analysis, training and model execution. An add-on has been developed on the Data Mining Orange tool that offers a complete set of tools for its exploitation and is integrated with the platform.

Cognitive

The platform offers a set of APIs ready to use in the API Manager of the platform that facilitates AI capabilities such as text analysis, entity extraction, translation between languages, image analysis, OCR and TextToSpeech. Users can also create new APIs on the platform's Marketplace offering interesting models of use and payment.

Report Engine

This engine allows the generation of reports that are managed from the platform. These can be generated from the dashboards themselves or through integration with Jasper Reports, in which case the template that consumes data from the platform will be uploaded to the platform via REST API, facilitating the generation of the report in different formats.

DataHub

In addition to the supported databases, the platform deploys and integrates with Hadoop, which supports the main distributions along with Cloudera and Hortonworks, integrating them via HIVE, Impala, Presto, Kudu, Hbase, etc. to accommodate Big Data scenarios that require large storage and processing capacity.

Onesait Platform Things modules

IoT Broker

IoT Broker is a component that allows sensors, gateways, legacy systems and smart nodes to communicate with the platform in a bi-directional way. Various IoT protocols, including MQTT, COAP and Kafka support automation protocols such as OPC-UA, and offer client APIs for different languages to make communication with the platform as simple as possible.

Device Management

Device Management System is a web application that allows the user to remotely manage all the intelligent nodes deployed at the edge, as well as control the sending and receiving of information from low-power devices. A console facilitates managing and operating devices with hybrid IoT solutions. It offers two-way communication with the devices without the need for the physical presence of a technician. MS supports the dev/ops loop on the distributed environment of devices supporting different OTA mechanisms.

Synoptics

This component is designed to create hybrid IoT systems in which the platform's edge and cloud capabilities can collaborate, facilitating two-way communication with devices for the rapid modelling and implementation of dashboards. This synoptic functionality is very useful in industrial scenarios where there is a need to monitor and act upon physical signals. Synoptics allow the user to create dashboard and SCADA-like representations in real time.

Digital Twins

This component implements the Digital Twin concept using the semantic model based on the Web Things API (Mozilla). It facilitates the auto-generation of the code of the twins to be deployed at the edge in Javascript format and provides a broker (Digital Twin Broker) for its connection with the cloud. The extension with Flow Engine allows defining collaborative twins environments in the cloud.

Edge Engine

Edge Engine is Minsait's commitment to build a rich architecture of containers at the edge that permits data to be processed wherever it is generated. Edge Engine increases response speed and data security while reducing communication costs. It provides the tools to manage the component life cycle, as well as a set of useful protocols and services.

Workload Consolidation

The Unified Hybrid IoT Framework for Industry, based on Kubernetes distributed clusters, is a management tool for real-time computational support in plants with heavy operation workloads . It allows the deployment and management of automation acquisition elements through RF and wired networks as well as the use of ML algorithms with low latency.

Programming languages

The platform is designed mainly in Java (Spring Boot). But the following languages can be used to interact with the platform:

- Dashboards – JavaScript, angular, html5, css3.
- Flow engine – JavaScript.
- Streamsets – JavaScript and sql.
- Notebooks – spark, r, python, sql.

5.4 Set of operational IT solutions for integrated city management

The axes and actions of the Smart Logroño project are the following:

1 Internal Axis aimed at municipal services:

- Dissemination, promotion and implementation of the "smart culture" that fosters a change in the service management model based on efficiency and re-use of resources, the evaluation and monitoring of indicators and the use of georeferenced capacities.
- Development of the different vertical and thematic projects identified in the Master Plan.

- Attention and monitoring of the contracting of projects and acquisitions of devices and infrastructure for their adaptation to established standards while guaranteeing their integration with the smart platform.

2 External Axis aimed at interoperability and capture of external data.

- Agreements for the exchange of data with CAR, Ecoembes, SAIH, etc.
- Collaboration with the Smart Territory / Region project.
- Integration with CON21 2016/0112.

3 Citizenship Axis aimed at citizens, organizations, companies and entrepreneurs of the city.

- Complete the deployments of the smart and Open Data portals.
- Projects for the dissemination of knowledge of smart cities such as collaboration with the University of La Rioja and the unemployed with visits arranged to the Integral Control Centre.

4 Technological Axis aimed providing smart means and resources:

- Complete the technological evolution of the new version of the platform.
- Complete the expansion of resources and infrastructure.
- Collaboration with other facilities of the platform.
- Increase data analysis capabilities.

5 Logistics Axis aimed at the management of means and resources:

- Put someone in charge of the Smart Building to undertake its management and maintenance.
- Management of OGP development teams.

6 Strategic Axis aimed at collaborating in strategic municipal projects:

- Open government, transparency and accountability: automation of ITA indicators and content, budget viewer, planning, dissemination and monitoring of projects, and citizen participation.
- Comprehensive tourism management: Smart Destination Logroño, Camino de Santiago, collaboration with La Rioja Tourism.
- Building management.
- Electronic administration.
- Other municipal plans: Equality Plan, Logroño Verde, and others.

The Smart Logroño project is based on three basic pillars: the Smart Building, the comprehensive management platform for municipal services, and the integration of infrastructure and communication networks.

Smart Building

In the open-plan room with the largest surface area, the Smart Building houses the Integral Control Centre, a symbol of the integration of resources, and the main channel for dialogue with the public. It integrates single telephony for citizen service, and traffic regulation services, urban transport and public lighting.

Integrated management platform for municipal services

The Integrated Municipal Services Management Platform constitutes a fundamental element of Logroño as a smart city as it orchestrates the capacity to achieve and increase multifunctionality, creates a central repository of information and control, and achieves a higher level of coordination and efficiency.

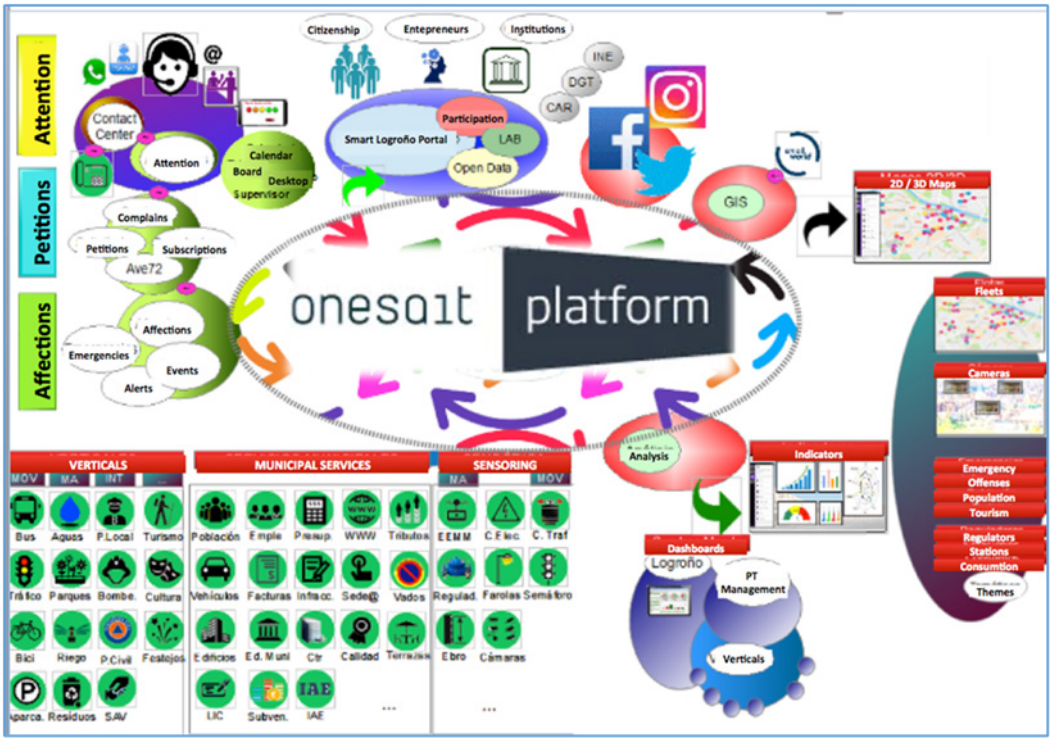
The core of the platform is based on Indra's FEEP IoT & Big Data Platform Sofia2, which provides basic capabilities such as data capture and standardization from the Internet of Things (IoT), and from other external systems – online and historical mass storage – combined with other sources of information, data analysis, development of indicators and statistics, generation of rules and alerts, as well as presentation on maps and 3-D viewers.

Around this core, several common modules have been developed to improve relations with citizens for care, request management (including complaints and suggestions, 72-hour breakdowns, information requests, subscriptions and requests for visits), management of conditions on public roads and emergencies, and event management. Citizens can access all of these municipality services using a common short telephone number "010".

In addition, it provides support for georeferenced content management, as well as for the management of indicators and dashboards at the city council, the platform and for integrated urban services.

Finally, the platform has two portals aimed at citizens: the Smart Logroño portal and the open-data portal.

Figure 12: General vision of Logroño Smart City



The evolution of the platform has been done on the Onesait platform, evolution of Sofia2, including:

- Conditions and incidents on public roads.
- Citizen services.
- Municipal heritage assets.
- Public employees.
- Weather stations.
- Fines.
- Citizen participation.
- Water cycle.
- Municipal budgets – general viewer and management tool for budget managers
- Social media.
- Traffic regulation.
- Urban transport.
- Tourist accommodation.
- Telephone service (call centre).
- Proceedings of local police certificates.
- Surveys.
- Urban planning licenses.
- Economic area standards.
- Municipal heritage.
- Population (register of inhabitants).
- GIS Resources – layer integrator.
- Cast masks.
- Territory. ITEs viewer.
- Request viewer: complaints and suggestions, faults, etc.

It also includes global tools for data management and viewing:

- Layers for platform managers.
- Entities of the city.
- Indicators of the municipal transparency system.
- Geoportal.

Infrastructure and communication networks

Smart Logroño encourages the integration and use of resources. It supervises the capacities of servers and storage, and also manages the traffic and security cameras of various municipal systems in a unified way.

Smart Logroño includes an infrastructure deployment strategy based on the efficient and evolutionary use of resources to complete a communications network capable of structuring the city and integrating the different technologies that enable the connection of sensors, devices and buildings that make it possible to implement the rest of the systems.

The deployment includes connection services for the implementation of video cameras, traffic access control, electric lighting panels, traffic regulators, Wi-Fi in public areas, access to corporate MAN and 3G/4G connectivity.

The connection of municipal services with the main data centre, along with the rest of the corporate and other networks such as the SARA network (set of communications infrastructures and basic services that connects the networks of the Spanish Public Administrations and European Institutions) and the Internet is guaranteed with the deployment of the main fibre-optic ring, as well as the connection of secondary equipment and a 3G/4G network which, owing to their location, could not initially be incorporated into the fibre network.

In addition to providing citizens with information, it integrates the municipal switchboard with a call-centre platform and the management modules of care, requests and conditions so that the care data are directly integrated into the corresponding management modules and into the platform's common repository.

Figure 13: Infrastructure and communication network

5.5 Governance

The Smart Logroño Development Commission (CDSL) is responsible for the strategic direction of the project. Its functions extend to the strategic, technical and operational aspects related to the Smart Logroño project, among which the following main objectives are to:

- Evaluate the achievement of different objectives and the socio-economic impact of the projects and actions carried out.
- Verify the compliance and quality of the products obtained.
- Execute, coordinate and carry out the monitoring, as well as the technical and economic regulation, of the actions envisaged within the scope of the Smart Logroño Public Services Management Platform contract.
- Prepare, execute and monitor a strategic plan for the improvement and transformation of municipal services. This is aimed at pursuing efficiency, sustainability and innovation, as well as the different plans and projects to incorporate services in the management platform, including the development of criteria and procedures for action.
- Consult, plan, coordinate, monitor and control the actions, projects and resources assigned for their integration in the management platform of vertical services, and the rest of the municipal services.

The CDSL has a changing and flexible composition. It maintains a permanent number of members, primarily from the economics and technology sectors, including a team of managers and technicians from vertical urban services.

The CDSL is supported by the Project Management Office (OGP), which comprises three municipal technicians: a coordinator, a person in charge of networks and infrastructure, and another for the platform and development. Also included are personnel from the companies that were awarded joint venture status, or UTE: two for the needs of the platform, consultants specialized in the different areas, and a team comprising a project manager, two developers, a BI specialist and a GIS specialist for the integration of verticals.

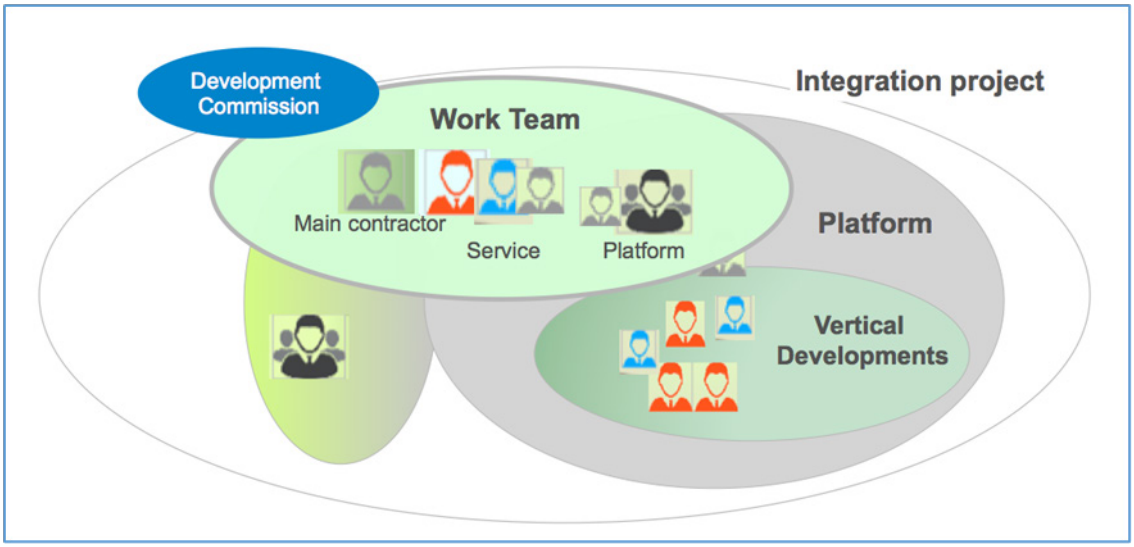
The main actions of the CDSL include:

1 The approval of unified supervision for the management and deployment of infrastructure resources and the communication of existing networks in the city council, which were hitherto maintained as islands and isolated from the rest of the areas. The objective is to avoid duplication. Knowledge and information on contracts are sought for better management of the networks and to generate cost savings.

2 The introduction of integration clauses in the technical specifications of public contracts that can manage some type of data for Smart Logroño. This clause obliges the successful bidders to develop, in collaboration with the OGP of the city council, a two-way integration of the data identified and the use of the tools and capabilities provided by the platform.

3 Establishing an integration model of the verticals, training the work team, collaborating with the development team and supervising the CDSL.

Figure 14: Structure Smart Logroño Development Commission



5.6 Economic sustainability

The Smart Logroño project began in 2014 with the creation of a multidisciplinary working group to prepare the project's strategy and contract specifications. Initially, Smart Logroño's financing lines

were based on contributions from the city's major service contracts, which had been processed at the same time. The synergies and advantages derived from the use of a common platform include:

1 Funding for mobility and lighting, along with the contract for the 010 information and non-emergency telephone assistance to citizens that financed the launch of the platform.

2 The rest of the city's main contracts would finance their own integration with the project.

Given the administrative complexity of this solution in the Spanish public procurement system, a firm commitment was made to have an urban platform with its own financing through a specific public contract designed to build the city's data infrastructure. Despite the administrative difficulty of this solution and its compatibility with the Spanish public procurement system based on past experiences, it was decided to proceed, and the contractual agreements were carried out successfully.

The third file, CON21 2016/0053 separated the contracting of the platform from urban service contracts. The necessary financial resources were provided entirely from the municipal budget without any type of aid or subsidy. The final award to the joint venture alliance (or UTE) set up by the company Indra along with the local company Sumainfo, was EUR 1 786 633.05 (VAT included). With an initial four-month basic implementation phase of the Sofia2 platform and another four more for the full development of the additional capabilities and functionalities, a development and maintenance phase of the platform was entered into for the four-year contract period.

The new strategy of separating the awarding of the contract for the platform from the vertical services contracts also included a common contract for the developments necessary for the integration of urban services and municipal IT systems into the platform.

The amounts of these contracts have been charged to the IT budget, currently under the General Directorate for Technological Modernization.

The ability to share information from the platform with entrepreneurs, researchers, and others, and the collaboration projects with the students of Computer Science and the University Master's degree in information technology at the University of La Rioja do not include revenue for the city council.

Smart Logroño provides facilities, along with direct and indirect improvements in communication with citizens while creating synergies and savings between integrated urban services. It also provides common tools to improve data management, the generation of added value, and building capacities for analysis and decision making. In addition, it complements the management of municipal systems with spatial data and indicators while facilitating the monitoring of municipal activity. There is no monetary assessment of the advantages it brings, but undoubtedly it makes a significant contribution to the transformation towards a smart and sustainable city management model.

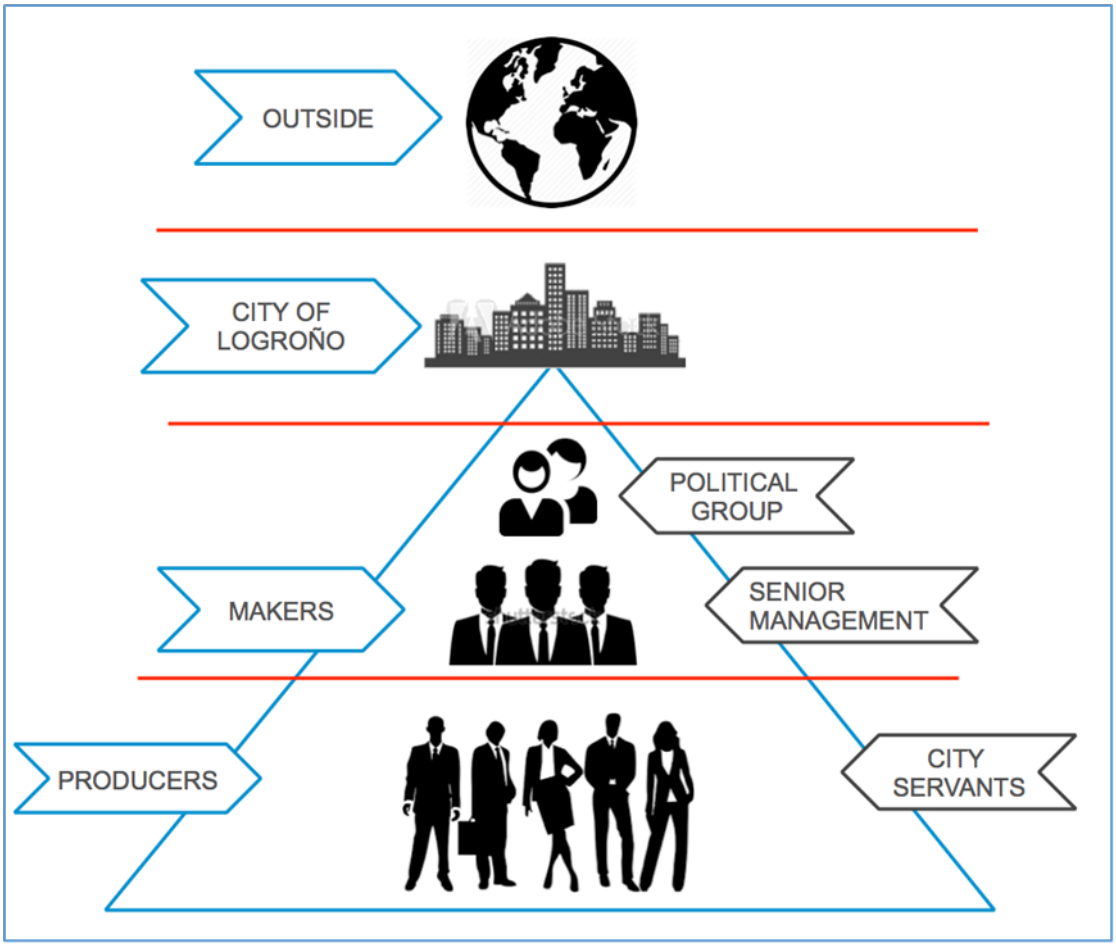
5.7 Key Factors and Barriers to Implementation

A key factor prior to the implementation of a smart city strategy in the city is the need for a clear, objective and shared approach to the project by political and technical leaders. It is a long-term, strategic project with a broad scope that includes the entire organization. A project to create a paradigm shift in the entire management model with radical changes in management style needs to introduce measures to allay concerns people may have of rejection and the fear of information being "stolen" or of being "watched" or "controlled" by Big Data-backed systems that function like islands. It is not an accumulation of individual or pilot projects; it requires a global platform and far-reaching strategic planning.

The project seeks to promote a cultural change that enables the evolution of a passive and receptive citizenship to an active, participatory and super-connected environment. In addition, it embodies a shift towards an efficient and sustainable government by changing the management model and on a process of evaluation and continuous improvement based on verifiable indicators.

The project includes the data and systems of the entire organization and is designed to integrate with citizens and other external systems. It involves all municipal services and at all levels of the organization. It implies a complicated execution process, developed in several phases. It also envisages a long-term political outlook and is not suitable for those looking for short-term gain.

Figure 15: Levels of the organization



The change in the management model is based on:

- Monitoring, evaluation and improvement of management practices and projects at all levels with the incorporation of KPIs and geopositioning data.
- Re-use / Efficient: the platform configures a space to share:
  - Information – basic and complex.
  - Human resources – urban services, citizen services, ICT development.
  - Material means.
  - ICT resources – software for horizontal applications and common development, as well as infrastructure and communication networks.
- ICT capabilities:
  - Big Bata approach (for storing and managing large amounts of data) and an open-data approach (for making platform data easily available).

- Captaining data of diverse origins and types.
- Integration with georeferenced data.
- Monitoring and alerts, generation of indicators and dashboards for monitoring the city and municipal management.
- Analysis and prediction of data and facilities for decision making.
- Integration with municipal and external systems.
- Relationships with citizens (including external organizations and companies and entrepreneurship).

The final objectives require continuous progress and investment in human and economic resources that can be implemented in vertical services, as well as in a centralized way. These are "smart investments" as they are conducted with a global perspective of the organization and aimed at maximizing return on investment.

As the project progresses and the systems are integrated, the managers involved have begun to see the advantages of being part of the project and the improvements that have accrued. By overcoming the hurdles in project implementation, they provided the continuity and support required to carry out the integration of services and to initiate an escalation of interest that facilitated the establishment of a smart culture throughout the organization. The support and contribution from technological partners such as Indra, a technology company of the highest level, along with Sumainfo, a local company, were among the key factors that contributed to the transformation into a smart city.

Another aspect that contributed to the success of the project was the dissemination of information internally, within the organization itself, and externally, sharing experiences, knowledge, data and developments. Participating actively in the network of smart cities (including the one in U4SSC) and collaborating with other city agents were also contributing factors.

5.8 Stakeholders' involvement

Smart Logroño is a global project that transcends the limits of the city council to cover all areas of the city.

A smart city is one that places people at the centre of the decision-making process, while promoting active and participatory citizenship. Smart Logroño has a clear objective in facilitating and enhancing communication with its target audience. It has developed management tools that facilitate the work of their agents at the municipal call centre. The information is automatically integrated into different modules, which eases the tasks of management, the generation of indicators and their publication in dashboards along with geolocation information, where appropriate, and making them available to citizens through the various portals.

Smart Logroño promotes projects for the dissemination and knowledge such as:

- Visits to the Integral Control Centre of the Smart building.
- Collaboration with the University of La Rioja so that students of the computer science degree and the University Master's degree in information technology can conduct studies on the municipal platform.
- Creation of a network of meteorological stations in educational centres of the city.
- Cooperation programmes with the unemployed to know and provide services in smart projects.
- Dissemination workshops among Logroño students of different ages.

In addition, it promotes collaboration with nearby companies and projects such as the Ecoembes' TheCircularLab, which promotes innovation in the field of packaging and its subsequent recycling. It encompasses the concept of a circular economy, making data available to entrepreneurs and citizens, along with content of the platform through the smart, open-data and API portals.

6 *Montevideo Inteligente*

6.1 Strategic vision and purposes

Montevideo is considered to be a smart city that seeks to improve the quality of life of its citizens with an inclusive and sustainable approach using innovative solutions to encourage participation, promote environmental care and develop quality public services. The city and the country stand out for their quality of life thanks to a series of policies implemented in recent years. The civil rights agenda, diversity and tolerance as a watchword, and an emphasis on care for the environment are central elements. Innovation and technology are also key levers to achieve productive development, along with the rational use of resources and citizen participation while encouraging the enjoyment of free time. From *Montevideo Decide* (Montevideo Decides), a digital platform for direct participation by citizens, and from a "Participatory Budget" for projects proposed and selected by citizens, people interact and participate in decision making and in the implementation of public policies in a two-way dialogue, with priority accorded to forging gender perspective and transparency. There are no smart cities without smart and engaged citizens.

The use of transversal platforms, the Internet of Things, data science and artificial intelligence enables all areas of the organization to be managed with advanced technological tools and to offer quality services to citizens. Data constitute the oil of our time; their ownership, availability, preservation and use for the improvement of services are a great responsibility. Finally, sustainability and resilience are considered to be the most important challenges. Minimizing the environmental impact in the present and thinking about their impact on future generations, promoting the necessary change of habits and customs, along with the introduction of good management practices are seen as clear

priorities. The reference framework of *Montevideo Inteligente* constitutes a milestone towards the future development of a diverse, innovative, enterprising, enjoyable and liveable city.

Context

It is common to find in the best examples of smart cities around the world an internal and/or external "trigger" to catalyse the formation of a powerful and successful smart cities department. In the case of Montevideo, the external catalyst is the extent of digitalization in Uruguay – a process that has accelerated over the last ten years. In fact, Uruguay is the leading country in Latin America in digital government and is integrated with the D7, the most digitalized group of countries in the world, which includes Canada, Estonia, Israel, New Zealand, Republic of Korea and the United Kingdom. At the same time, another important catalyst has to do with the fact that Uruguay has had a strong strategy over the last ten years to promote the innovative ecosystem, betting on projects in which private companies, public institutions and academia participate jointly. Uruguay has an ICT industry in the order of USD 1 billion, which is constantly expanding, with more than 700 technology companies exporting software to 52 different countries. Uruguay is also the main software exporter per capita in South America and the third in the world. In this context, Montevideo is part of this national process, betting on transversal management based on artificial intelligence techniques and data science, in accordance with the strategies of the most advanced smart cities.

6.2 Governance and financing

At the beginning of the 2015–2020 government cycle, the municipality of Montevideo had a technology division that was part of the urban planning department. However, the growing availability of information made it imperative to prioritize technology as a tool to make better decisions at the general level of the institution.

In this context, when the five-year budget was presented for approval in July 2016, the Department of Sustainable and Intelligent Development was created. The department was born with the broad-based objective of creating a smart city (based on the integration of new digital technologies) in order to improve management processes. The improved quality of life of citizens with an inclusive and sustainable approach was envisaged with a focus on the rights agenda, diversity as a slogan, and care of the environment as a priority.

Among the instruments used, the Smart City Technology Management area was created to provide the necessary technical support to the policy of *Montevideo Inteligente*, and the MVDLAB was created as a laboratory of innovation and citizen participation.

To manage this process, the Advisory Council for Intelligent Cities was created, comprising of representatives from AGESIC, the Agency for the Development of e-Government and Information Society and Knowledge, and the ANII, the National Agency for Research and Innovation, and universities. This Council has had wide participation in the validation of the strategy and in the decision-making process to develop the organizational structure. The creation of an

interdepartmental network of digital government was proposed, and it took the lead initially by assuming the Presidency. There are multiple collaboration agreements with AGESIC, the Ministry of the Interior, the Ministry of Economy and Finance, the Ministry of Transport and Public Works, ANTEL, ANII, BPS, DGI and DGR. Collaboration agreements were signed with the city of Buenos Aires, with which Montevideo participated in the 2018 joint stand at the Smart City Congress in Barcelona. Montevideo has presented the smart city strategy at nine international congresses.

All the projects of *Montevideo Inteligente* are financed with its own funds.

6.3 Montevideo Smart City Platform

The smart city platform is the information system that facilitates the collection of data from sensors and meters, the executing of commands on actuators, as well as the handling of data flows of great volume, speed or variety and their storage and processing (Big Data). It also offers real-time or offline analysis of information and the visualization in georeferenced form on maps, dashboards and panels or graphics. It enables the integration of databases and computer systems from different verticals and businesses to process information and knowledge to support the decision-making process. It also makes it possible to exchange information with other platforms, applications or external systems in a secure environment, while allowing for the publication of open-data or open services for use by external organizations or applications.

The Smart City Technology area management supervised the selection and implementation process to establish the smart city platform through market research and analysis of solutions, pilot and prototype designs, interviews with suppliers and city governments (Barcelona, Buenos Aires, Santander and Malaga), comparative experiences, and attendance at expos and exhibitions. Subsequently, it prepared specifications for the call for tenders to implement the project. The FIWARE platform, an open-source platform based on standards developed by the European Community, was selected; this is aimed at the implementation of intelligent solutions. The FIWARE ecosystem currently reaches more than 150 cities, 22 iHubs and acceleration programmes for companies and solutions based on the standards, in addition to participation in standardization bodies. FIWARE was chosen because it is easy to implement and it guarantees interoperability and integration with portals for open-data and open services. It is also a very powerful open-source platform, which facilitates the use of context information in a massive way. It was later used in Uruguay as a platform for IoT in another national company in addition to a FIWARE iHub. Several other companies developed products for this platform:[8] [9]

Real-time applications and services

The smart city platform facilitates the analysis and visualization of information in real time for different applications, internal, as well as for use by citizens. Among other applications, the GPS positions of units of the public transport system are available[10] , including the position and routes of vehicles of the Municipality of Montevideo (IdeM) and those of the collection companies. Data are also collected from air quality sensors, sound meters, meteorological stations, applications of

geofences (an alarm sounds when a vehicle passes through a geographical area, which is useful for things like garbage dump monitoring and fleet control), and displays on control panels.

Open data and services

The Montevideo API public portal[11] provides a service API with platform information (including in real time) to developers through a self-managed portal. This mechanism is used for the publication of information for third parties such as the estimated time of arrival (ETA) at the bus stop of public transport units, which is used by the ComoIr application of the IdeM, as well as by applications from external companies. The same mechanism is used for interconnection with other platforms such as Moovit, Waze, the National Port Administration and the Institute of Meteorology.

Data analysis applications

The Big Data tools associated with the smart city platform, along with the ability to integrate different sources and verticals have made it possible to work with data from the Metropolitan Transport Systems STM (electronic ticket sales), including the real-time positions of buses and the systems associated with the Mobility Management Centre or corporate systems of the Montevideo City Council (city sewer and sanitation system, Unique Claims System and the GRP). By applying data analysis techniques, different applications have been developed:

- Algorithm to deduce the destination bus stop from users of the public transport system, based on upcoming trips and historical card information.
- Origin/destination matrix with visualizations according to neighbourhoods, lines, schedules or time periods.
- Service levels of the fleet, compliance with schedules, routes and times of passage by stops.
- Line-occupancy levels, occupancy prediction, and application as an aid to control during the COVID-19 pandemic.
- Model of bus stop occupancy levels.
- Analysis of travel times.
- Analysis of use by type of user served to establish frequent user policies.
- Traffic, accident and speed applications.
- Applications on the cleaning and waste collection system of the city, location of the garbage containers and lifting control.
- Analysis of consumers of city sewer and sanitation systems.
- Real-time analysis of alarms and indications of data network equipment (logs) for prediction of failures.

6.4 Montevideo Inteligente: applications for everyday life.

Montevideo manages traffic through the Mobility Management Centre (CGM), using the best available technologies to guarantee safety, smooth traffic and compliance with regulations. The public transport system has an electronic ticket system based on the STM card. Constantly evolving, it is available across the entire metropolitan area, including for use on inter-urban transport companies, as well as the ability to pay for taxis and trains. The prepaid STM card can be linked to personal bank accounts and to new accounts at recharge points. Among the projects of *Montevideo Inteligente*, the Challenge ANII (the National Agency of Innovation and Research) has developed a pilot to test different technological applications on board public transport units, aimed at helping to improve the experience of users and the quality of service offered. This includes the linking of accounts in the cloud to equipment on board the buses. Connected to a central online infrastructure, it facilitates payments from a mobile phone with the possibility of taking advantage of flexible fare plans throughout the day or the week, with variations in seasonal rates or on demand such as promotions for shows or specific activities.

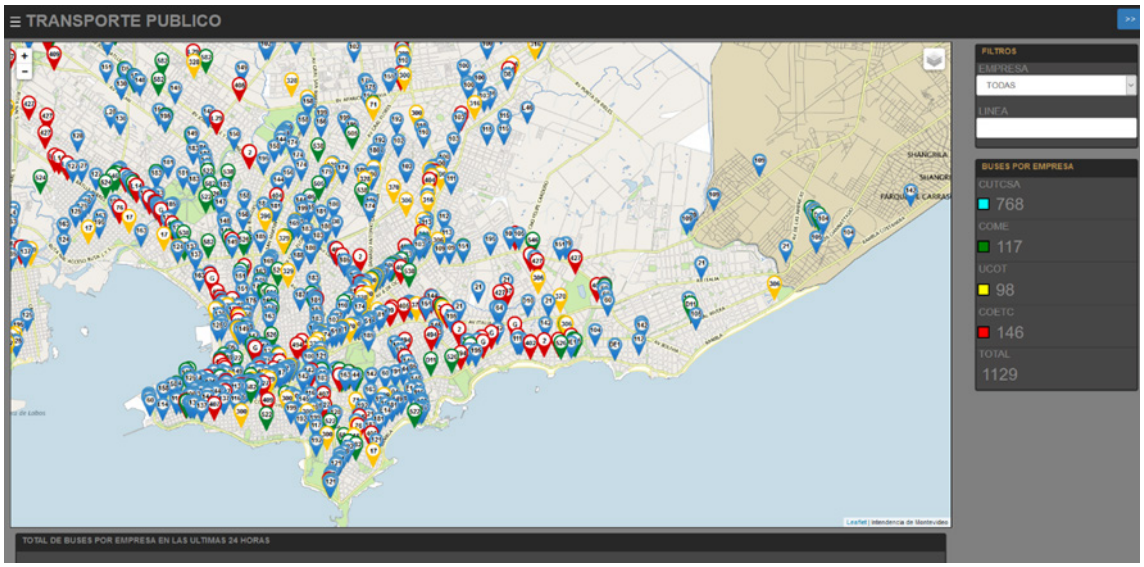
The smart city platform FIWARE is a critical component in the development of services associated with mobility. It processes data and facilitates services associated with traffic (vehicle numbers and speeds) and public transport (bus location and ticket sales). The information is available for internal use and for publication as data or services to be used by citizens. This makes it possible to offer applications to citizens such as the "How To Go" service, an app to schedule trips and get real-time information on the location and arrival time of buses. Other applications for internal use utilize Big Data technologies and analytics to enable planning tools such as maps and representations of origin/destination, as well as infra-red maps, analysis of behaviour, of supply of and demand for public transport requirements, or tools to measure the quality of service based on compliance with committed schedules and frequencies. The Digital Proximity (*Cercanía Digital*) project establishes a two-way dialogue through social networks and digital communication channels, seeking to understand sentiments through natural language recognition and providing answers in a quick and friendly way.

6.5 Challenges ahead

- Include data analysis in all the departments of the organization. Promote policies associated with data science and predictive analysis based on information generated in management systems and data extracted from the IoT platform.
- Promote data economy by increasing the use of the MVD API portal for the publication of services of the data generated by the city for the improvement of public services for its citizens, NGOs, academia and companies.
- Consolidate the Operational Centre of Montevideo (COM) by improving the coordination and operational efficiency of the organization through the smart cities platform, identifying and communicating through different channels, and evaluating possible difficulties that may be encountered in the various public services.

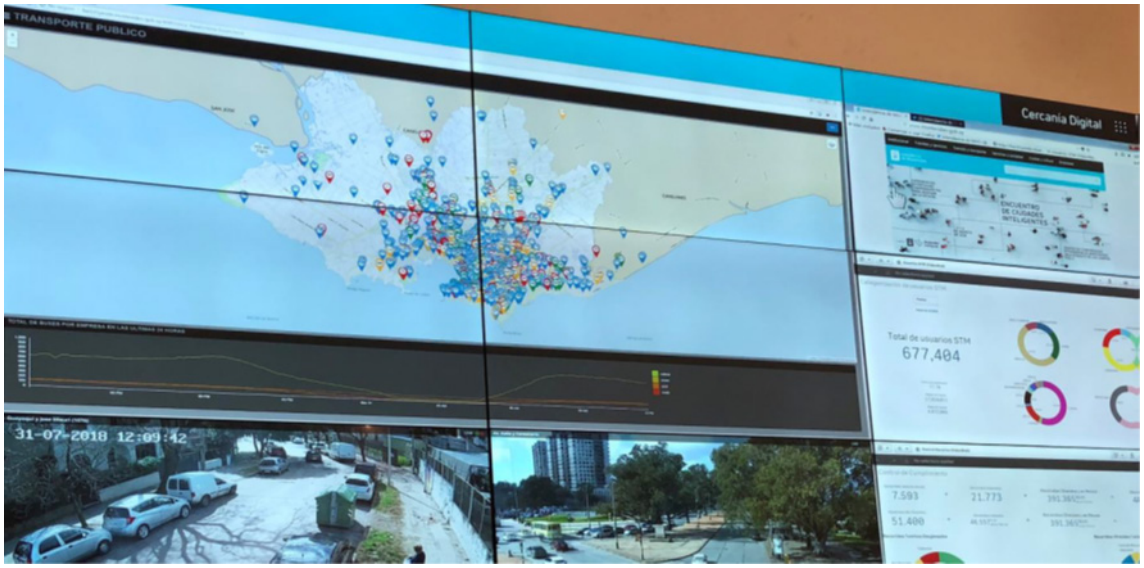
- Improve communication with citizens, centralizing multiple communication channels and analysing data collected on platforms such as social networks, looking for trends and carrying out research on language and interaction with citizens.
- Develop applications for cleaning and waste management on the FIWARE smart city platform such as tracking collection trucks, verifying container lifting and using sensors to monitor the filling of special containers in order to include, manage and make decisions regarding these services.
- Implement the remote management of the LED technology public lighting system, which, in addition to the advantage of reducing the cost of public lighting, includes the implementation of an IoT communications network that will facilitate the installation of sensors throughout the city in a more economical and scalable way.

Figure 16: Public transport GIS map of Montevideo



Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of ITU and of its secretariat concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Figure 17: Integrated city dashboard of Montevideo



7 Rivas Vaciamadrid

7.1 City profile

The first traces of population in the geographical area of Rivas Vaciamadrid date from approximately 2 300 years ago, when a folder house was established within what is now the municipality of a place known today as Miralrío.

The history of Rivas Vaciamadrid has been marked by its proximity to the city of Madrid. It owes its name to Captain Guillermo Rivas who in the 11th century, colonized the area creating a Christian enclave, by order of King Alfonso VI. Vaciamadrid may also derive its name from the Arabic expression *Manzil Mayrit*, which means *Parador de Mayrit*, a place where travellers heading to the city stopped to rest.

In 1845, Rivas joined Vaciamadrid, calling itself Rivas del Jarama. It marked the union of two villages with houses scattered around large farmlands .

During the Spanish Civil War, it bore the brunt of the Battle of Jarama due to its strategic location and was destroyed. The town was rebuilt in 1954 by the General Directorate of Devastated Regions and was developed with numerous limitations, reaching around 500 inhabitants at the end of the 1970s.

At the beginning of the following decade, construction began of the first of the buildings to be inhabited by cooperative members. It was then that its demographic really began to take-off and by 2020, the population of Rivas had grown to almost 92 000. This is the steepest demographic progression of any European city in recent decades.

Seventy per cent of the municipality comprises the South-East Regional Park, where the Jarama and Manzanares rivers converge. The city is located less than 15 kilometres from Madrid, and it has three stops on the Madrid metro network.

Rivas is an open city, with wide streets surrounded by green spaces, parks and groves. The municipality is contiguous to a natural park, the Parque Regional del Sureste, a protected area of 31 552 hectares at the confluence of the Jarama and Manzanares rivers in the south-east of the Community of Madrid. Rivas occupies 76 per cent of its municipal area. Its natural wealth boasts fertile cereal plains, gypsum cliffs in the hills, groves and riverbanks and numerous wetlands and lagoons. There are also archaeological and paleontological sites in the area.

7.2 Strategic approach.

Planners at Rivas Vaciamadrid are aware of the need to have a strategy to structurally address development aimed at promoting innovation in the services provided to citizens and business, in line with the model of a sustainable and open city. For this reason, it began its digital transformation

project in 2004 with the deployment of technological infrastructure based on fibre-optics. This has enabled convergent hyperconnectivity of all the verticals in the city such as energy, environment, reduction of the digital divide, electronic administration, energy management, security, mobility and governance. These measures have reduced energy consumption and the carbon footprint considerably, while improving the quality of life and public services for the citizens.

The variety of projects being implemented in the city of Rivas have made it a benchmark of modernity, while guaranteeing the productivity and well-being of its citizens. Its smart city model – along with its energy efficient and CO_2 reduction policies embodied in the Rivas Zero Emissions Plan and the enormous deployment of fibre-optics and the Wi-Fi network –are clearly aimed at creating an innovative city based on a sustainable socio-economic model. This objective has been amply supported by the implementation and development of the Rivas 2030 strategy and the commitment to make rational and intense use of ICTs to improve the effectiveness and efficiency in the management of public services contemplated in "Rivas 21.20 Digital: the Digital Agenda for Rivas Vaciamadrid".

The Rivas City Council made the decision to bet on the "Smart" development of the city, in order to manage municipal resources more efficiently and effectively, and to improve the quality of life of its citizens. Proof of this is its membership, since June 2012, of the RECI as one of the 25 founding cities. It currently holds the Vice-Presidency of the RECI and co-leading Working Group 2 on Green City: Sustainability and Infrastructure. It also participates in the AENOR CTN 178 Standardization Committee on "Smart Cities", leading the infrastructure subcommittee where the first City Platforms Standard 178104 was agreed, along with ten other standards.

7.3 Technological architecture of the urban platform

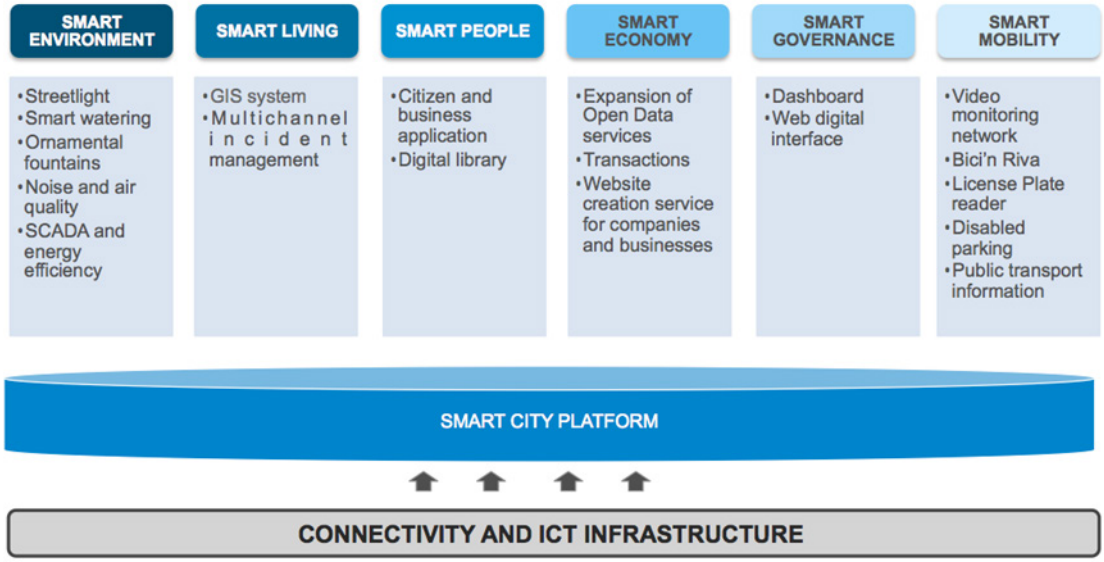
This platform initiative specifically contemplates the development of three major interdependent and complementary actions:

1. The smart city platform contains and relates to all smart city systems.
2. Integrate and improve the existing or planned expertise or vertical solutions of the city council that are part of the smart city platform.
3. Expand and improve the city's ICT infrastructure as enabling elements of a smart city.

From a graphic point of view, the initiative is defined as the following:

It enables the transformation process of services from a comprehensive point of view and the application of open-data policies that favour the establishment of an open and participatory innovation ecosystem that is robust, secure and adaptable, and transparent in the management of public services.

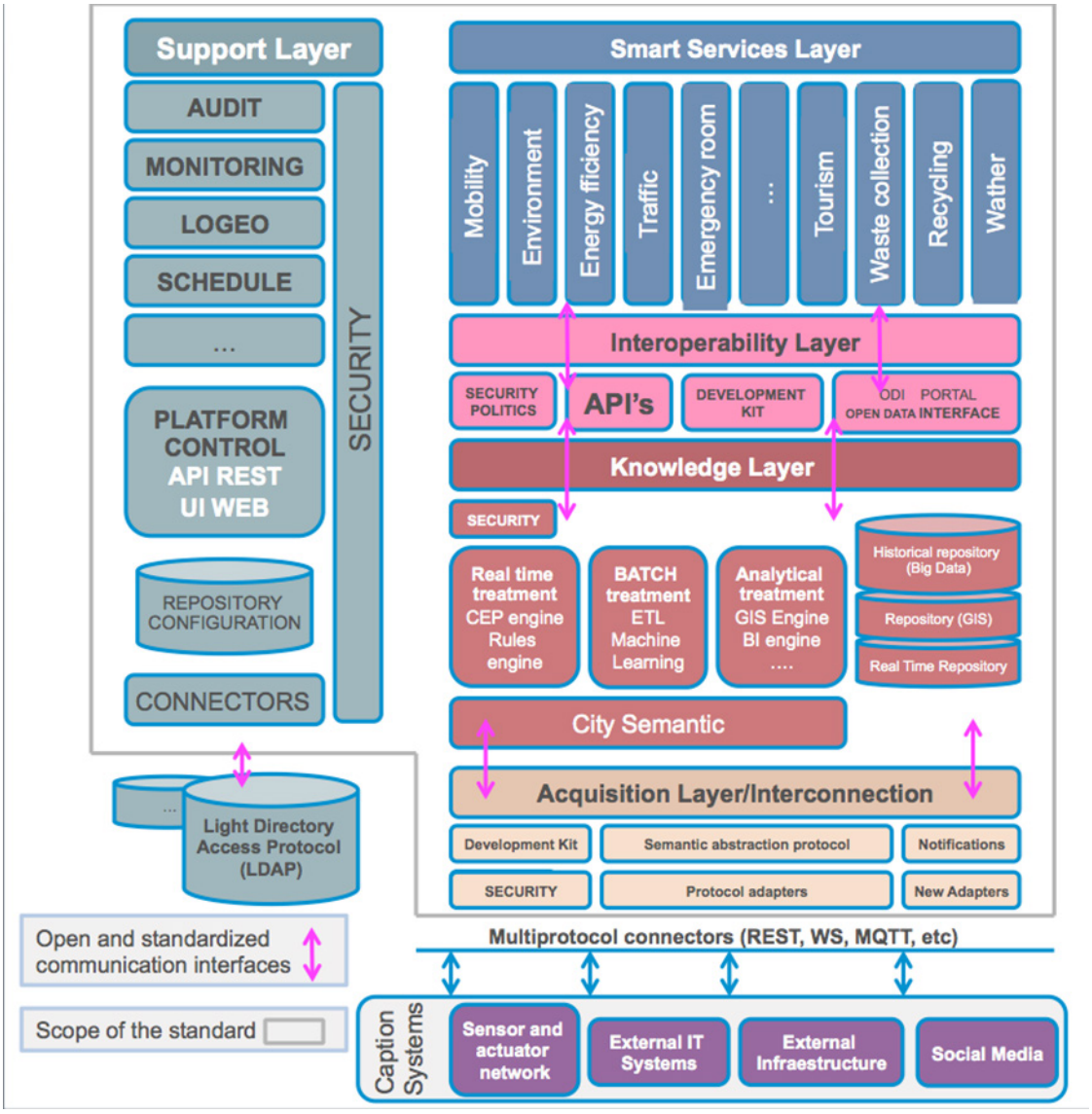
Figure 18: Vertical strategy developed on the platform



The platform includes all software and hardware elements that enable the production of smart solutions and their horizontal management. It contains all the necessary elements for the reading, reception, transformation, extraction and storage of data, publication of information, monitoring and reporting, and also incorporates Business Intelligence (BI) tools and Dashboards.

The platform is based on the Spanish standard UNE 178104: 2017 model and complies with the characteristics set by the Rivas Vaciamadrid City Council. It is based on open standards and technologies, which are horizontal, interoperable, heterogeneous, scalable, robust, resilient, adaptable, extensible, modular, comprehensive and have high-performance, availability, security and privacy.

Figure 19: Layers of the smart platform model in Spain. Standard UNE 178104: 2017



The platform facilitates the operational management of the elements of acquisition, transformation, publication and storage of data independent from the vertical management solutions of municipal services that are implemented on it. It acts as an intermediary among the different systems that make use of the data and the sources of origin of this data such as information systems already existing in the city council, as well as other external systems and sensors deployed by the city and directly connected to the platform.

The platform enables the city council and other public and private entities to use it appropriately to promote innovative smart cities developments, while preserving the integrity of the system and the data.

The platform will be based mainly on components subject to open-source licensing, in order to facilitate its re-use and dissemination. It will also enable its use by other local entities with the possibility of implementation without dependence on a pre-determined supplier.

In all developments and applications, the use of free and open-source software is prioritized as far as possible.

The platform facilitates integration with diverse data sources and multiple structures through a Big Data approach. It will be able to amalgamate information from sensors and actuators managed by the city (e.g., traffic lights, street lights, irrigation of parks), as well as from citizens' devices (such as mobile phones), structured, non-structured and semi-structured data, social networks and data streams and other IT management systems such as SCADA – Supervisory Control And Data Acquisition, Big Data sources (streaming listening) and management solutions implemented in the city council.

This component abstracts from the acquisition mechanism and the origin of the data (e.g., device, ICT system, log) enabling the implementation of semantics established and validated by the city council, among others FIWARE.[12]

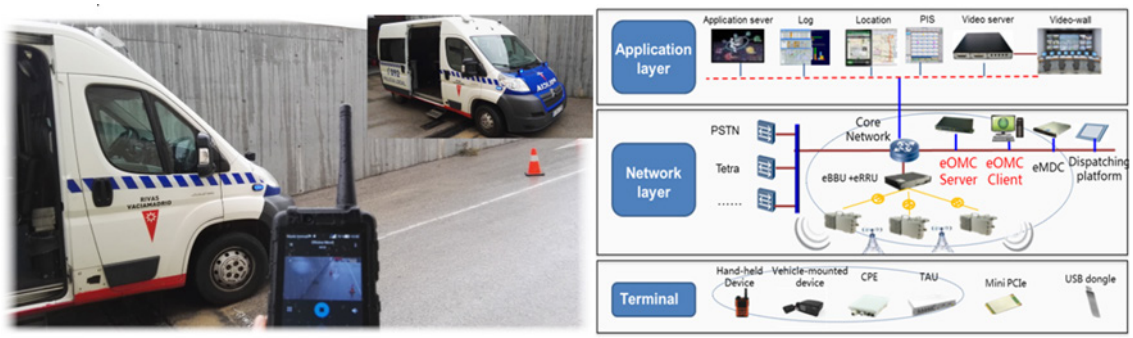
The platform enables integration with standardized open M2M and database messaging protocols, as well as web services and files, which have specific connectors with the main protocols used in the IoT world, including HTTP, HTTPS, MQTT, MQTT-S, CoAP, REST and XMPP. They support lightweight structured file formats such as JSON, GEOJSON and Ultralight 2.0. The platform also supports IPv6-based communications and sensor connections that make use of specialized protocols such as 6LoWPAN and LPWAN-type access technologies, including LoRa, NB-IoT, Cat M and Sigfox, which provide the corresponding connectors for current and future elements.

7.4 Set of operational IT solutions for integrated city management

The Riv@Smart platform aims at the true interoperability of smart services deployed vertically with the different independent management systems of each service. The most prominent are:

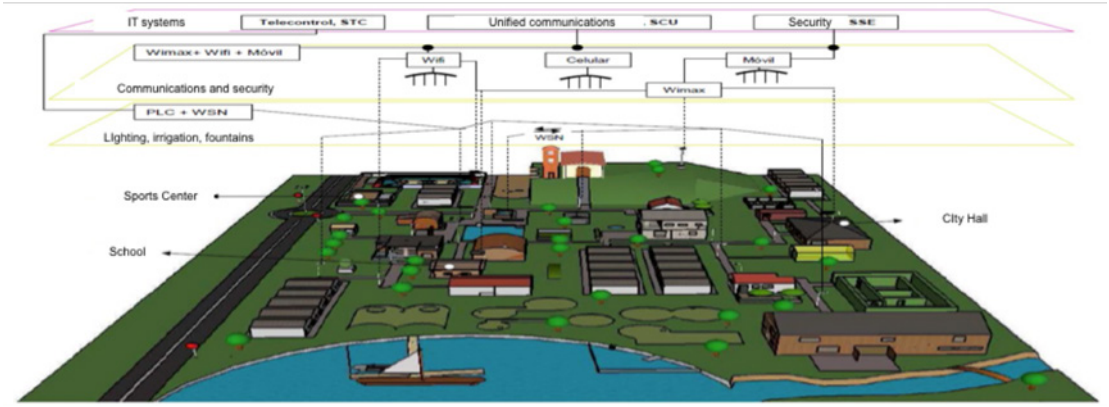
- The entire infrastructure of the IP multiservice network supported by Rivas Vaciamadrid, based mainly on fibre-optics that converge with other infrastructure, Broadband Plc, IoT NarrowBand, Wi-Fi (Wifi4EU), LTE-Security and emergencies.

Figure 20: LTE *security and emergency interoperability scheme, multiservice network interoperability*



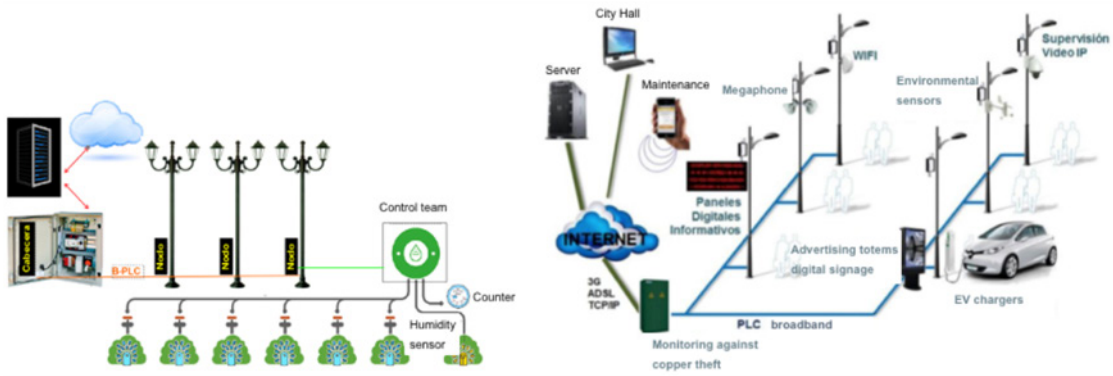
- This hyperconverged infrastructure with more than 20 Gbits in the 86 municipal buildings and exterior of the city (150 cabinets), along with the monitoring and follow-up of the corresponding KPIs facilitates the interoperability of all smart services in the city.

Figure 21: Scheme of interoperability with different technologies, public and private.



- Rivas Vaciamadrid has deployed a total of 4 000 points in intelligent lighting and irrigation sensors with the intention of reaching 13 000 points in the coming years. These lamp posts use Dali protocol dimmable LEDs connected to the intelligent interaction of the video analytics of traffic control cameras that enable a reduction in consumption and CO_2 emissions in the atmosphere, saving electricity consumption of up to 80 per cent and reducing water consumption by 19.2 per cent while increasing the life of the LED luminaires. In addition, this broadband PLC network enables the electrical power cable to piggy-back as a telecommunications network of between 2 and 30 Mb for the connection of different IoT devices. It also provides electrical power to the devices such as air quality stations, information panels, traffic cameras and electric vehicle charging points.

Figure 22: Smart broadband PLC network scheme, smart lighting and irrigation

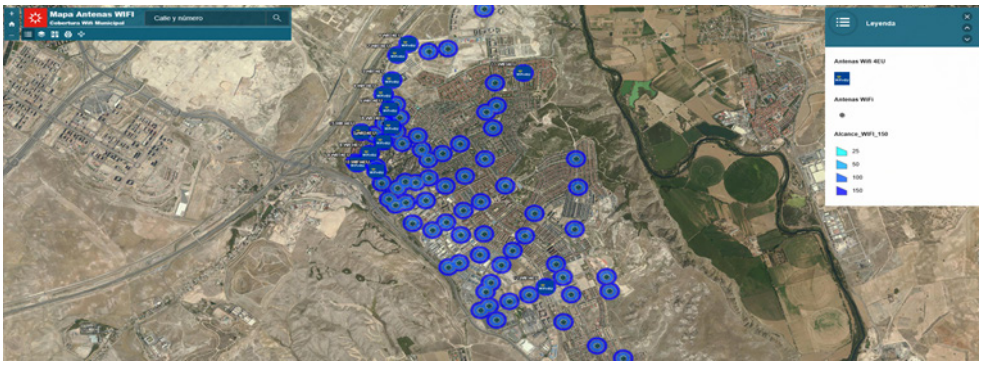


- The IP video surveillance network, using video analytics, has several advantages such as increasing the security of the city, improving traffic management and traffic jam detection. It also aids in vehicle counting, traffic speed data, reading licence plates and interaction with the lighting system to reduce consumption or increase luminosity in emergency situations. During the COVID-19 pandemic, it has also been used to control capacity or mobility.

Figure 23: Control panel for capacity, social distance and mobility

- The Wi-Fi network has been deployed in 100 per cent of public buildings with a total of 630 4x4 indoor MIMO APs and 130 outdoors, enabling anonymized data mining for the intelligent management of lighting, air conditioning and device status. Since 2006, all educational centres have hyperconnectivity, which has stimulated and facilitated digital education, reducing the digital divide in the city.

Figure 24: Exterior Wi-Fi Coverage Plan and WIFI4EU

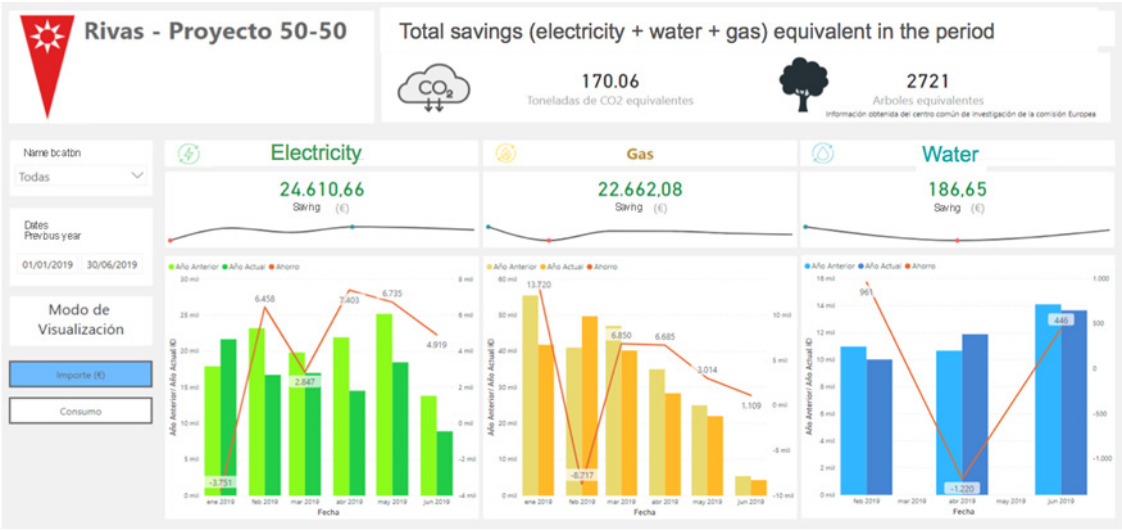


- The Supervisory Control And Data Acquisition (SCADA) system of the Rivas City Council for buildings and sections of the public highway manages more than 8 000 control points (sensors and valves) that transmit information related to temperature, water systems, electricity, fires and energy requirements of the buildings and facilities of the town hall. There are 39 buildings that have different types of remote-controlled automation. These are grouped by sectors, ranging from administrative services, educational institutions (schools) and sports facilities to economic development and employment, the environment, citizen security, social services, sources of irrigation, culture and festivals. These intelligent services automatically optimize the levels of comfort, temperature, humidity and CO_2 in the main buildings, emitting alarms if the stipulated levels are exceeded and, in the event of water leaks, supervising the correct operation of the facilities, issuing warnings in case of incidents and triggering automatic actions. It complies with the UNE-EN-ISO 50001 standard for energy management systems.

Figure 25: Services implemented on SCADA

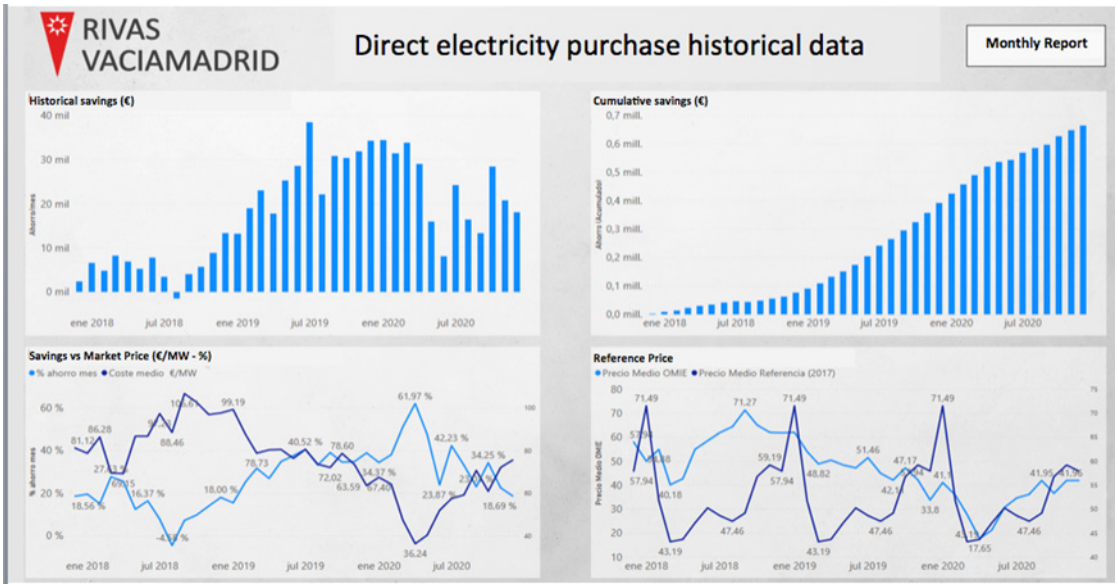
- The energy manager is an analytical tool that monitors the operation of buildings, measures against optimal rules and generates KPIs with alerts and incidents. The system detects opportunities for optimizing the operation of buildings, saves energy with energy efficient management of the facilities and extends the useful life of the equipment. For example, the 50-50 Project is a collaborative programme with the educational community that enables citizens and schoolchildren to visualize the total savings per school in electricity, gas and water consumption, as well as reduction of CO_2 emissions. Half of the economic savings achieved annually – amounting to an average of about EUR 48 000 – is for the educational centres themselves and the other half is used by the city council to invest in improving educational centres, as agreed with the energy managers, who are the schoolchildren.

Figure 26: Scorecard and savings KPIs 5050



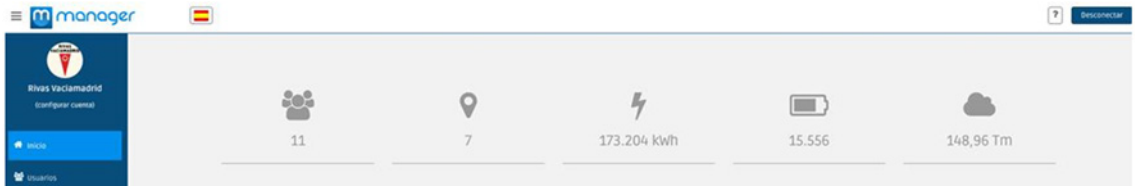
- The direct purchase of energy in the free market and the sale of energy from photovoltaic production generated from more than 35 photovoltaic installations, and two reserved for self-consumption have resulted in large economic savings as well as reduction of CO_2 emissions, which are critical elements in the Rivasmart strategy.

Figure 27: Scorecard and Savings KPIs direct purchase of energy and smart actions



- Mobility and air quality are other projects on which the smart city strategy has focused. Currently, there are a total of 21 electric vehicle charging points boosting sustainable mobility.

Figure 28: Dashboard of the 11 charging points for vehicles and electric scooters.



- The monitoring network is configured with six fixed stations at selected points and six mobile stations that represent areas of interest for controlling air quality pollution in the municipality. These fixed network units include air quality and noise monitoring sensors, as well as meteorological sensors.
    - Air Quality Stations with high resolution gas sensors – in expected measurement ranges of ppb- (NO, NO_2, CO, H_2S) and an Opticle Particle Counter (OPC) sensor
    - OPC for sampling of PM1, PM2.5 and PM10.
    - Type 2 sound level meter for Laeq sound level measurement.
    - Sensor for wind speed and direction, temperature, relative humidity and atmospheric pressure.
    - Mobile units have been deployed in police vehicles through the security and emergency LTE to collect data from the entire municipal area.

Figure 29: Mobile Air Quality Stations over the LTE-E network

- The IoT NarrowBand is a sensor network that is used for different services, including:
  - Care for the elderly with cognitive impairment using location bracelets.
  - Control and location of municipal assets:
    - Plastic fences: location of fences in the municipality and detection of vandalism or theft.
    - Cleaning carts: location of cleaning carts.
    - Other generic assets.

  Monitoring of parking spaces, with special emphasis on spaces for special use such as disabled spaces and spaces for loading and unloading .
- This comprehensive security system ensures increased efficiency in the use of the facilities. Thanks to Mifire and NFC technology, public employees, contractors and members of associations with appropriate permits can access buildings with a single card, deactivate alarms in the centres, programme opening hours with the capability of remotely opening the centres, as well as controlling fire alarms. In addition, in the case of educational centres, the intercom system has been integrated with the Wi-Fi telephone concierge system that can open doors remotely. This system comprises more than 22 000 sensors that are connected with the city platform through the SCADA system to control lighting or to ascertain which buildings are the most efficient.

Figure 30: Comprehensive Security and Access System Scheme

- The Licence Plate Reader system to control mobility in the municipality has functionalities that go beyond video surveillance of vehicles entering or leaving the municipality or to control mobility by type of vehicle and traffic. Its artificial intelligence algorithms facilitate the detection of traffic jams and accidents. These events are presented and highlighted in real time at the local police control centre.

The Unified and Economic Management Panels facilitate the evaluation of georeferenced data along with more than 380 existing indicators and information of interest such as the management of current expenses, the average period of payment to suppliers and pending administrative tasks, all of them broken down by municipal services and areas.

The re-use of the open-data of the city platform, the interoperability and integration of the commerce platform, the city app, centralization of databases and the municipal geographic information system have facilitated the development of a scorecard that shows the state of the city.

The city platform has made it possible to make a Transparency and Open Data portal available to citizens and companies in which more than 60 data sets are published in 200 different formats, accessible through the web or through APIs CKAN openings for third parties.

The city app, connected to the different verticals, integrates all the information related to the city in a single environment that facilitates the completion of administrative procedures.

During the COVID-19 crisis and the heavy snowfall during the Filomena storm, which adversely affected the entire community of Madrid in January 2021, a new municipal website was developed and published on which citizens could consult all the information on any issue related to the pandemic or the havoc caused by the snowfall.

7.5 Governance

Since the process of digital transformation was initiated in 2004, the Rivas Vaciamadrid City Council has revamped its services, adapting year after year to new requirements. In 2020, it created the Department of Innovation and Modernization with the following objectives:

1. Promote and evaluate the execution of the "RivaSmart" initiative and its projects, guaranteeing the achievement of the objectives based on the city council's guidelines.
2. Gather the know-how generated in the course of carrying out the projects to form a centre of knowledge and specialized professionals, which would facilitate the sustainability and future evolution of the RivaSmart City model.
3. Study the relationship between the objectives of the initiative, as well as the projects included in it with possible additional financing models (e.g., public-private collaboration, aid or subsidies at the European level).
4. Communicate the results and benefits derived from the initiative to those responsible for the Rivas Vaciamadrid City Council and to Rivas society, while extending the bases of the smart city to all the agents that interact with it.

The establishment of a management and control entity in which the different departments of the city council are involved, constitutes two main elements for the success of the transformation of Rivas into a smart city:

1. It is the organization that controls and disseminates the strategy and the initiative, assuming the functions of evaluation and validation of the projects.
2. It is a consultative body that promotes the culture of creating a smart city, taking advantage of the knowledge acquired through the implementation of the different projects that make up the initiative, as well as promoting its re-use in the local environment and in the social and business fabric of the city.

The Innovation and Modernization Department comprises an interdisciplinary team of 21 people who manage the administrative, strategic and technical processes. They are, in turn, divided into specific verticals, each taking charge of departments such as the Comprehensive Citizen Service System (SIAC), Electronic Archives, Facilities and Telecommunications, Digital Services and Systems and Delegation of Data Protection and Transparency. All these depend on the head of service responsible for all the implementation and monitoring of the RivaSmart strategy.

All the elements have been summarized previously, but a key element is that a smart city requires quality connectivity. In the case of Rivas Vaciamadrid, it is achieved with the deployment and distribution of its infrastructure to all operators in the municipality. This has energized the bandwidth and reduced the digital divide among citizens, companies, services and municipal contracts. The deployment of 4G and 5G services has had a dynamic effect in the municipality, and some operators have used the optical fibre installed by the Rivas Vaciamadrid City Council to deploy connectivity.

Rivas Vaciamadrid is one of the youngest and most continuously growing municipalities in the territory. The Department of Innovation and Modernization has issued guidelines with specifications for the deployment of smart systems for new innovations and for those that need to be reformed. In addition, all the technical specifications include specific smart clauses, which for years have greatly simplified the growth of the platform. These clauses involve information, semantics and frequency data that must be included in the specific platforms, as well as in the city platform.

The data integration is very uneven, but above all, the focus is on real-time data obtained from the various sensors deployed across the city.

One of the main focuses of the RivaSmart platform is the evolution towards a knowledge economy that would benefit companies and entrepreneurs, researchers, journalists and society in general to have access to the city's data and the information provided by the platform.

7.6 Economic Sustainability

The Rivas Vaciamadrid City Council has received financial assistance through the Integrated Sustainable Urban Development Strategy (ISUDS Strategy) in line with the objectives of the Europe 2020 Strategy aimed at the growth of a smart, sustainable and inclusive city. The ISUDS Project for the development and implementation of the Integrated Sustainable Urban Development Strategy has been defined by the city council and designed together with the public in mind and in line with the Europe 2020 objectives and the Operational Growth Programme. All these actions are co-financed by the European Union and the city council, each contributing 50 per cent.

A total of EUR 345 000 was invested in 2020 to develop the base of a comprehensive platform. It was envisioned as the city's nerve centre, which would consolidate the existing and future vertical systems to meet the needs of the city in terms of mobility, environmental health, governance, people's well-being and so forth in a single, holistic cross-city system that would truly constitute a smart city.

Other projects that have been carried out during 2020 such as the development of a City app, as well as an e-commerce platform that was designed to be interoperable with the city platform and co-financed by the ISUDS strategy for EUR 147 000.

The total amount of the project funds in the ISUDS strategy until 2023 is EUR 1 559 743.00, of which 70 per cent has already been invested in developments related to vertical projects and city platforms. Outstanding outcomes include the installation of intelligent lighting and irrigation systems, air quality monitors and noise probes, as well as energy diagnostics in public buildings and a new digital library.

By way of example, 100 per cent of municipal investments to the tune of EUR 1 035 000 went to different projects of the smart ecosystem to improve the electronic administration platform, electric vehicles with intelligent management, electric vehicle charging points, hyper-converged servers, analytical systems of video, lighting and irrigation improvements, Inmotics and SCADA control

systems. The investments also were diverted towards managing capacity for COVID-19 intervention and air quality management in public buildings to manage CO_2 and control COVID-19 infection rates. All the projects are merged with the RivaSmart platform.

All investments made by municipal subsidies have an impact on returns due to direct savings in supplies such as electricity, gas and water, and the optimization of processes or value-added services to improve the quality of life of citizens.

Obtaining aid in previous projects can be considered as quantifiable performance. Non-quantifiable returns are linked to better efficiency and management in municipal services.

Currently, the monetization strategy of the information contained in the platform has not been developed. The information provided to universities and research centres has been free of charge and arranged through confidentiality agreements with these institutions.

The improvements in strategic planning and operationalization of the city platform achieved by the dashboards in municipal areas have not been valued in monetary terms, neither have the resulting efficiencies achieved in administrative processes. In addition, enhanced production by local enterprises as an outcome of API data generated by the platform have not been accorded a monetary value and neither have endowments and funding of research projects provided by the platform to university departments aimed at improving their research capacity.

In conclusion, investments in the city platform have been wise and sustainable, resulting in direct and indirect benefits to the city, as well as providing tangible and intangible benefits for citizens and the socio-economic environment.

7.7 Key factors and barriers to implementation

The key factor in the digital transformation of the city was marked by the firm belief among political leaders that building a smart city would be important and beneficial. This was the starting point in creating a solid organizational structure and strategy, involving the entire administration and providing the economic resources that facilitated its implementation.

Overcoming hesitancy and convincing the leadership of the advantages helped remove obstacles in securing budgetary allocation for the implementation of the smart city platform.

One of the main barriers to its consolidation lies in the management of change that implies, on the one hand, contractual evolution and, on the other, the organizational and technological processes that lead to the development of transversal services on an urban platform. In this process, it is very important to have officials responsible for introducing the changes with the support of the government team.

As soon as city services start to use the services and solutions offered by the urban platform and obtain adequate support in their technological transformation, a turning point occurs in the constitution of the urban platform.

The public administration in Spain treasures high-quality, verifiable data as a valuable resource referring to all naturalized and legal citizens. Achieving true interoperability among platforms at all levels in cities, as well as in central and autonomous administrations, would help enormously in the areas of environmental, social, mobility and health concerns. They would also lead to more effective digital transformation of the society and to the creation of innovative public services aimed at improving the quality of life of our citizens and assisting business entities.

7.8 Stakeholders' involvement

Citizens are involved directly as they make use of services available for their convenience on the city platform. For advanced users, options are available through APIs to conduct apprenticeships or participate in other developments.

Thanks to an open architecture and a standardized connection procedure via smart clauses, municipal service management companies can send automated information on their operation of the service and the fulfilment of their contract obligations.

All new developments will be provided as open APIs of value-added urban services that can be seen as building blocks to improve city management. The data generated by the project will be published as open data, taking into account privacy and security. This is being considered for use by different universities that usually collaborate in other innovative projects of the municipality.

In addition, different research groups are using the data provided by the city platform to develop their own mobility and environmental projects.

8 Shanghai

8.1 City Profile

Shanghai, with a population of more than 24 million (including more than 9 million migrants), is the largest metropolis in China. It is one of the world's largest seaports and a major industrial and commercial centre of China.

Shanghai is under mounting pressure for functional transformation in the face of continuous population growth and environmental resource constraints. Hence the city aims to realize its motto, "Better City, Better Life" in the future.

8.2 Strategic approach

Shanghai first proposed a smart city strategy in 2010, and this has been reiterated over the past ten years. The construction of Shanghai's smart city has advanced from the stage of laying the foundation for the Information Superhighway to building a single-function application system. It has now reached the stage of promoting the integration and innovation of the applications. At present, the digital transformation of Shanghai is progressing holistically, involving all aspects, including economic life and governance.

The fundamental basis for planning and constructing a smart city in Shanghai is people-oriented and focused on people's livelihoods. The government encourages the participation of citizens and other social entities, in order to promote the comprehensive development of a smart city, while continuously enhancing the attractiveness, creativity and competitiveness of the city. The major objectives are achieving digital transformation, digital governance and building a digital economy.

8.3 Technological Architecture of the Urban Platform

Shanghai has built a "City Brain" architecture. This depends on data aggregation and sharing, network infrastructure development, system integration and collaboration, and the openness of an application ecosystem.

Data governance

Data are considered as the core resource of the City Brain. The Shanghai Municipal Big Data Centre was established by the city government in 2018 as a one-stop-shop service platform for "cross-level, cross-department, cross-system and cross-service data sharing and exchange for government, industry and social data". The Centre is designed to support the data ecosystem, primarily through data governance and coordination.

Network infrastructure

Shanghai has also accelerated the development of information technologies such as the Internet of Things, Artificial Intelligence and blockchain, and strived to strengthen cybersecurity.

Shanghai became the first "dual gigabit" city in 2020, achieving full 5G coverage in the downtown area and accomplishing a gigabit fibre coverage of 99 per cent in the city. In addition to the network, the city has deployed various sensors to build an "urban neuron system".

Moreover, the city has attached great importance to cybersecurity. It has supported the development of the cybersecurity industry, enhanced the security management of data collection, and raised awareness among citizens.

System integration and collaboration

Shanghai has promoted the integration of dedicated networks and information systems in various departments and areas by unifying portal integration, access management, user management, authorization management, resource management, and security protection. It has also established a cross-departmental collaboration mechanism and provided the technical foundation for cross-department and cross-level work.

Application ecosystem

Shanghai has taken the lead in exploring and advancing the open use of public data since 2012. Focusing on social credit, medical and health services, inclusive finance and other fields, Shanghai has established the Big Data Joint Laboratory. It has cooperated with various social entities to launch pilot applications and build the ecosystem, which has increased public participation and created several smart city scenarios.

8.4 Set of operational IT solutions for integrated city management

There are three typical operational IT solutions in Shanghai's city management: the data-centric online-offline integration of digital government, the integrated smart city operation system and the Digital Twin city.

The data-centric online-offline integration of digital government

Shanghai has been improving its online platform for government services, which enables remote access through a single website. The mobile terminal of the platform, Suishenban, has integrated more than 50 mobile terminals of all municipal departments in the city to provide the citizens with smart living.

The citizen cloud app Suishenban has expanded connectivity across almost every aspect of city life, including medical, education, marriage, pension, traffic, social credit and insurance. It could potentially cover all aspects of the lives of citizens. The data-centric, online-offline integration of digital government in Shanghai was illustrated as a case in the 2020 UN e-Government Survey Report.

Figure 31: The citizen cloud app Suishenban (illustrative)

The integrated smart city operation system

Apart from providing government services via a single website, Shanghai has also built the integrated smart city operation system to provide smart governance. The system has integrated various data from different departments.

Based on the cross-level, cross-department, cross-system and cross-service data collection and analysis, the government can monitor and manage all aspects of public security, emergency safety, ecological and environmental concerns, and community governance aimed at improved effectiveness and efficiency.

Digital Twin city

Shanghai has planned to build a Digital Twin city. Using data from satellites, drones, and sensors, Shanghai has succeeded in creating a complete virtual clone of the city in Unreal Engine with technical support from a private firm. Ultimately, the plan is to turn this model into a true Digital Twin that will be updated continuously in near-real time.

In the future, planners and operators will be able to gain insights for improving services, optimizing building systems and monitoring traffic flows. Designers can simulate ideas in a live city environment before construction and visualize the impact of decisions in advance.

Figure 32: Highly realistic Digital Twin model of Shanghai

8.5 Governance

Management team

Shanghai established a working group consisting of leaders from different departments to support the long-term construction of a smart city. There were several working groups in the early stages, including the Smart City Construction Leading Group, Shanghai Smart Public Security Construction Leading Group, and the Shanghai Joint Conference on Promoting Wireless City Construction. These groups were merged into one group in 2019. The Mayor of Shanghai is the group leader and directors of various departments are group members. This group integration is aimed at promoting cooperation between different departments to improve the efficiency of the smart city.

Smart city standards

Shanghai has strived to establish and promote the standardization of smart city construction, including data standards, technical standards and evaluation criteria. It aims to share and exchange data smoothly to enable connections between different sectors and to ensure the safety of the smart city operation.

Official assessment of city smartness

Shanghai has assessed the construction of the smart city annually. In 2013, it began to measure and evaluate the performance of institutional support, smart applications, Internet readiness and other perspectives. The assessment could evaluate changes following the implementation of the smart city project, in order to improve it and to provide guidance for future planning and construction.

Figure 33: Annual assessment on smart city of Shanghai

Governance reinvention

The smart city has revolutionized the modes of traditional urban management. It is not just a platform to use as many advanced technologies as possible, but is more committed to cooperation and interaction between the city and the public. Every citizen becomes a producer, governor, user and beneficiary of data, and participates in city governance in Shanghai.

Regional collaboration

Shanghai has promoted cooperation in the Yangtze River Delta and formed a "Smart Yangtze River Delta" co-construction mechanism. The data-centric, online-offline integration of the digital government project has been expanded to the Yangtze River Delta region, including Shanghai, Jiangsu Province and Zhejiang Province. This cooperation has further enhanced convenience for citizens and their means of livelihood.

8.6 Economic Sustainability

To ensure the construction of a smart city, Shanghai has adopted government investment as the main financing mechanism. While smart city construction is a long-term process that needs a lot of financial support, Shanghai encourages private capital to participate in the construction process in addition to government financing. A number of high-tech companies such as Internet companies and telecom operators have invested in smart city development.

8.7 Key Factors and Barriers to Implementation

Firstly, the construction of a smart city is a long-term and complex systematic project involving expertise and participation in a large variety of fields. It is necessary to make a long-term and comprehensive plan to build up the required cooperation and collaboration mechanisms across departments and sectors.

Secondly, the construction of a smart city should focus on people's livelihoods. Awareness of the people's actual needs could contribute to smart city construction efficiently, achieve intelligent operation of the city and bring the benefits of smart city construction to all citizens.

Thirdly, information infrastructure construction is the technical basis for smart city construction. The development of the network, sensors and other information infrastructure could lay a solid foundation for the smart city. The information infrastructure should be reviewed regularly and improved consistently.

One of the main barriers has been data sharing and exchange. However, this problem has been solved gradually by establishing management mechanisms, building data standards, and strengthening cybersecurity in Shanghai.

8.8 Stakeholders' involvement

The involvement of various stakeholders is significant for a smart city. The government should encourage citizens, experts and firms to make contributions.

Citizens

On the one hand, the Shanghai government understands citizens' needs through survey questionnaires, and it uses the information to improve smart city planning. On the other hand, the city organizes activities such as Smart City Experience Week to improve awareness and encourage the participation of citizens in the smart city.

Experts

Shanghai carries out smart city talent selection activities to encourage experts to participate in the smart city project. The city has built a platform for professionals to communicate and has organized technical training to create a pool of talent for the construction.

Firms

Shanghai encourages cooperation with related firms to build the smart city ecosystem. The high-tech companies play a significant role in the construction of the smart city, launching pilot projects and participating in the government procurement process.

9 Trento

9.1 Strategic approach.

Trento intends to evolve into a smart city using ICTs, not as an end in itself but as a means to innovate and improve services offered to citizens and businesses. Rather than becoming a digital city, its objective is to improve the quality of people's lives and to increase the well-being and sustainability of the city, while preserving its glorious history, unique features and traditions.

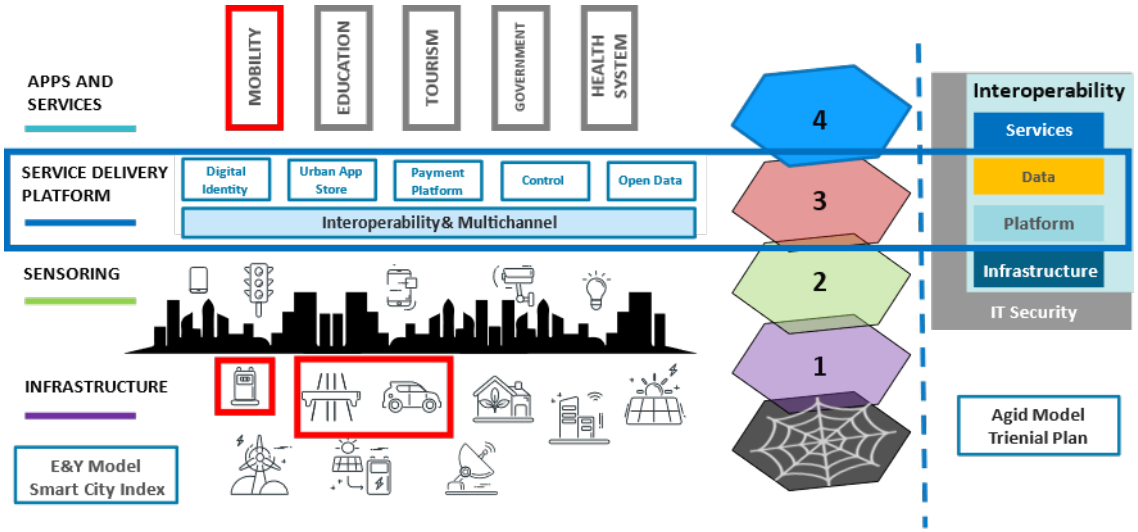
In order to achieve this objective, the city of Trento needs to develop a strategy and a holistic vision to avoid wasting resources while focusing on the general objective. Unplanned, knee-jerk measures must be avoided.

It is, therefore, necessary to set up a participatory process that involves citizens, businesses, institutions and all the other local stakeholders who can contribute meaningfully.

9.2 Technological architecture of the urban platform

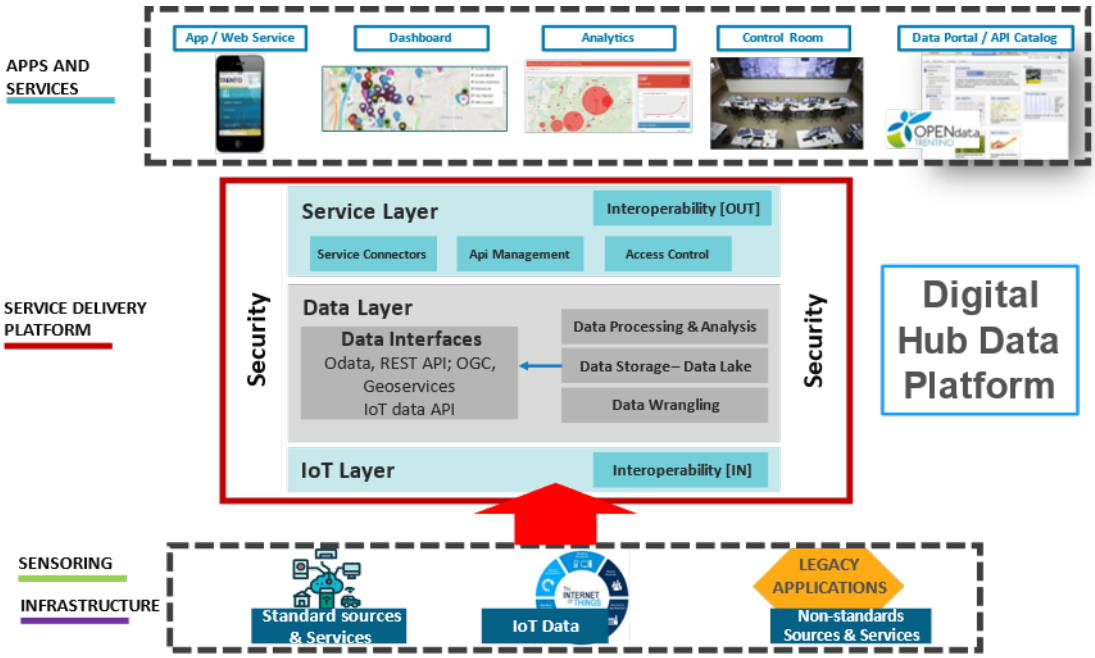
In terms of digital architecture, a new "operating system of Trento Smart City" is currently being implemented in collaboration with other institutional technological partners, and the Bruno Kessler Foundation (FBK) Research Centre in particular. The operating system consists of four horizontal layers (infrastructure, sensors, service delivery platform, applications and services) and is in line with the smart city models promoted by EY and described in the Triennial Plan by AGID – the Agency for Digital Italy.

Figure 34: Operating system



The core of the operating system is the "Digital Hub", the service delivery platform that enables the management of static and near real-time data that is derived from existing infrastructure. The Digital Hub exploits an interoperable interface that links legacy systems, different IoT sensors and all the sources and services that can be accessed via standard APIs.

Figure 35: Digital Hub

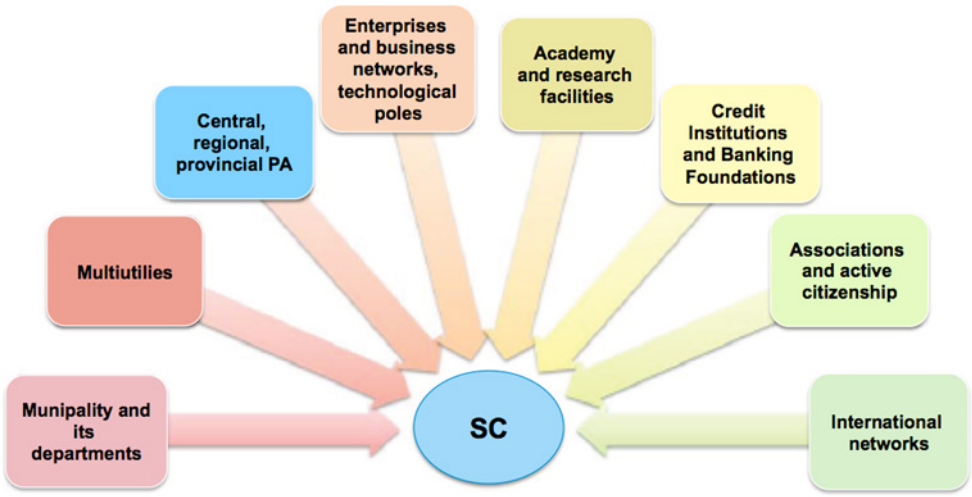


By exploiting single components of the Digital Hub, it is possible to manage, collect and classify all the data organically using a common framework based on international standards. Working on improving the quality of the original data and transforming it into useful information contributes to enhancing the value of public information assets. This initial research forms the basis to link and integrate data referring to different areas, which are seen as different sides of the same coin. It facilitates the transformation of information into knowledge, while building value-added applications and services upon the data. It also helps develop evolved analytics systems, which are able to support the decision-making process, as well as a genuine "smart city control room". Furthermore, it is of vital importance that such data be made available in an open mode, either as open data or through standard APIs, possibly in an unrestricted manner – or, if this is not possible, at least in protected mode to companies or public administrations.

9.3 Governance

To accomplish these ambitious objectives, the city of Trento has first and foremost focused at the internal level by taking political and organizational measures to achieve a functional coordination of the different institutions and to validate the smart philosophy as a cross-cutting approach throughout the whole Administration, while searching for useful links to the programming instruments.

Figure 36: Stakeholders Smart City



Moreover, the city of Trento has pursued the coordination of all local stakeholders who operate in different areas, each according to their own competences, with the aim of creating synergies and ultimately sharing the strategy, objectives and priorities. The city of Trento has signed agreements, conventions and memoranda of understanding with stakeholders such as the University of Trento, the Bruno Kessler Foundation (FBK), the Autonomous Province of Trento and the Consortium of the Municipalities of Trentino. It has acted as a facilitator among these stakeholders with a view to

setting up a successful many-to-many relationship. The objective of the Digital Agenda approved by the Municipality of Trento in 2020 is to reinforce the cooperation and synergy among all the stakeholders, private and public, who operate in the ICT ecosystem of Trentino.

9.4 Economic sustainability

The city of Trento needs dedicated funds in order to be able to achieve these objectives and to adopt the infrastructural and human resources that are necessary to implement all the actions, activities and projects. These funds can be accessed either from the annual budgeting process or via other project funding tools that are made available thanks to the alignment of the city objectives with those of the European and Italian agendas. The city of Trento can access sources of funding by submitting proposals in response to national, European and international calls while partnering with stakeholders of the ICT ecosystem of Trentino and other national and international stakeholders. All funding must take into account the need to "create and maintain value", leading to results that remain operative even after the end of the projects. Finally, different funding options based on innovative private-public partnerships have also been considered.

9.5 Key factors and barriers to implementation

Besides governance, the other critical factors concerning the implementation are:

- Competences.
- Organizational and technological innovation.
- Procurement and exploitation of economic resources.

Specific competencies in the fields of data science, service design, studies in social practices, behavioural studies and facilitation processes are necessary. Currently, the city of Trento does not dispose of such resources. A new approach aimed at introducing innovation and cross-cutting digital transformation in all the traditional sectors is much needed in order to switch from a traditional management logic based on watertight compartments to a culture of data sharing, enabling technological platforms and interoperable systems that make it possible to focus on cross-sectoral and multilevel scenarios while simplifying the processes.

9.6 Stakeholders' involvement

Besides institutional partners, private partners are also welcome to join the activities of the smart projects. The city of Trento actively promotes the inclusion of businesses, start-ups, associations and any other entity with a good reputation for excellence that is willing to develop and experiment with innovative solutions and that could contribute to its success at all levels. The city of Trento also aims to innovate with relationships with private stakeholders, shifting from its traditional role of "promoter" of smart projects – taking care of everything, from their implementation to their

promotion – to the role of "facilitator". The city provides the data it collects via its projects and thematic areas to third parties, allowing them to create new valuable services for citizens. It then assumes the role of "user" by making use of the data shared by third parties in order to make new services available for the citizens. The city of Trento intends to use this new approach to invest in the coming future.

Citizens too are considered valued stakeholders. Not only must they be involved in the discovery and usage of the innovative services that are available in the city, but they must also be included in the development and the evaluation of these services in all the different phases – from design to development and delivery.

With this in mind, over the years, many specific initiatives have been organized such as the "Trento Smart City Week" and the "Smart City Labs" events in all neighbourhoods of the city – in the main squares and parks, as well as in some secondary schools and senior centres. The aim of these events is proactively to help citizens develop digital skills, while spreading knowledge and understanding of the smart digital services, going beyond simply providing information about the currently available digital services. Great importance has been attached to events targeting minors and other categories at risk of exclusion, either for economic reasons or because of the digital divide, with the aim of extending and systematizing this practice in the coming years.

9.7 Other information of interest

Future Trends

Based on the infrastructure currently being implemented, and on the actions and projects in progress, the aim is to keep investing in combining technology with environmental sustainability, while shifting to a new paradigm enabled by the adoption of the "micro" approach in mobility and in the production of electricity.

The city of Trento also aims to adopt organically and apply Artificial Intelligence techniques to all the areas in which this is deemed feasible, useful and ethically correct. This is made possible by the increasingly larger amounts of data collected from the range of sensors in operation, which enables improvements in the algorithms adopted, as well as by the experience gained by the city of Trento and its technological partners in European projects that make extensive use of AI in well-defined areas. Investment is also directed towards other trends such as the use of drones and blockchain techniques in specific areas, aiming to increase the degree of confidence in the services that are managed in collaboration with citizens and businesses.

10 Valencia

10.1 Strategic approach

The digital transformation of the city of Valencia has been structured on strategic ICT plans to meet political commitments in the face of city challenges:

1 Comply with the Law of Electronic Access of Citizens to Public Services, Law 11/2007 of 22 June, which grants citizens electronic rights to interact electronically with public administrations. This commitment was developed on the Electronic Administration Master Plan for the period 2008–2014.

2 Become a Smart and Sustainable City. This commitment was developed on the 2013–2020 Smart City Strategy, articulating its evolution on a public urban platform tender.

3 Establish the Digital Agenda of Valencia as an element of ICT alignment with the needs of the city, as well as the transformation and convergence of ICT architecture in a robust and sustainable environment. It was developed in line with the 2018–2021 ICT strategy.

4 City reconstruction plan and definition of the Urban Agenda of Valencia 2030 was developed through specific missions of sustainability and resilience, one of the key areas being digitization.

The Smart City Strategy was based on a study of the level of smart maturity of the city's services in the implementation of its strategic direction and the introduction of technology. This study lays out a holistic integrated city management strategy to meet the needs of citizens based on four elements:

1 Strategic direction in the definition of key indicators for decision-making and their evaluation.

2 Technology in integrated city management looking for open technologies and a corporate information repository.

3 Operations in digital transformation and management of municipal services.

4 Governance models, in the evolution of the control centres and in the management of change through the use of the urban platform.

Figure 37: Smart City Valencia strategy

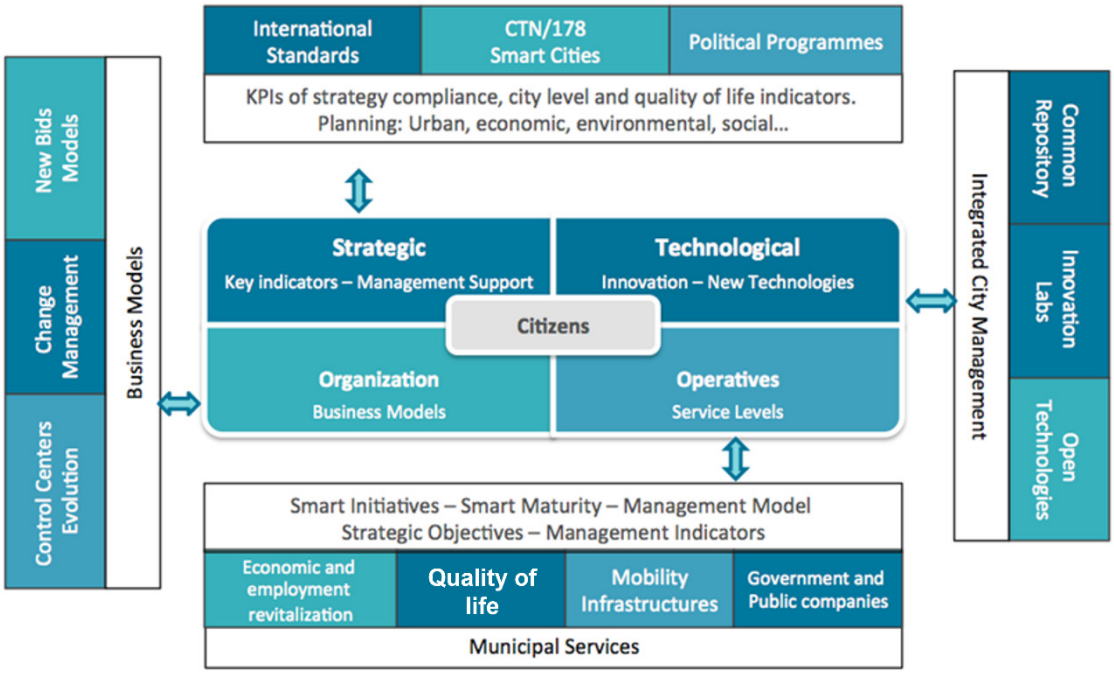
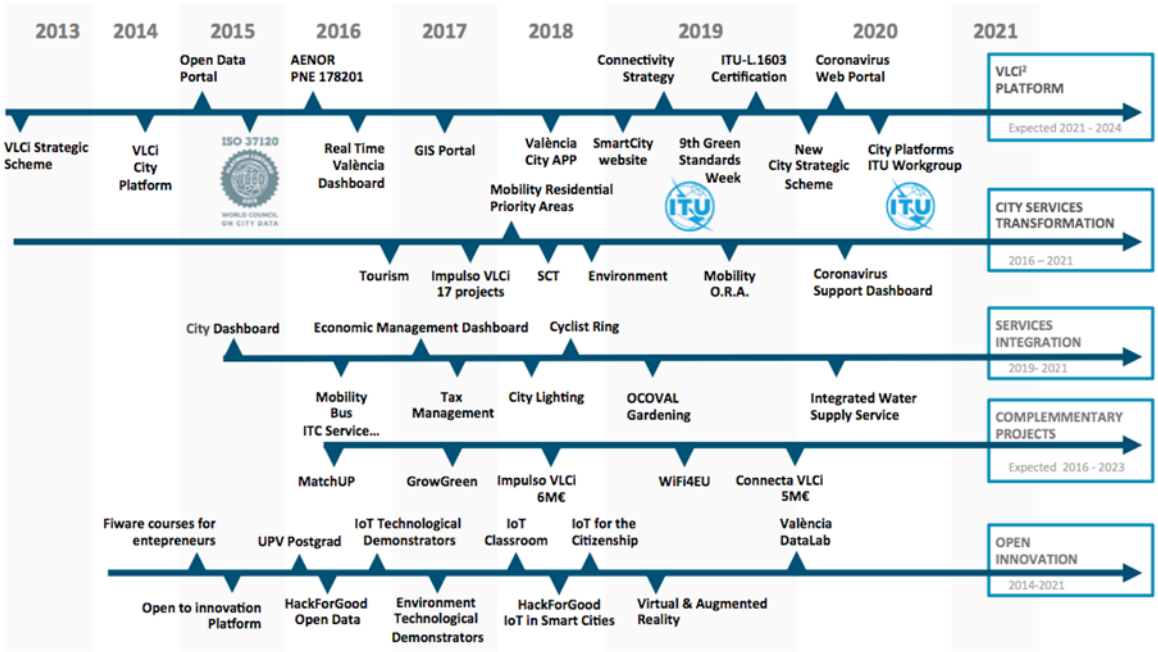


Figure 37: Smart City Valencia strategy

The following table summarizes the main milestones. [13]

Figure 38: Valencia smart city milestones

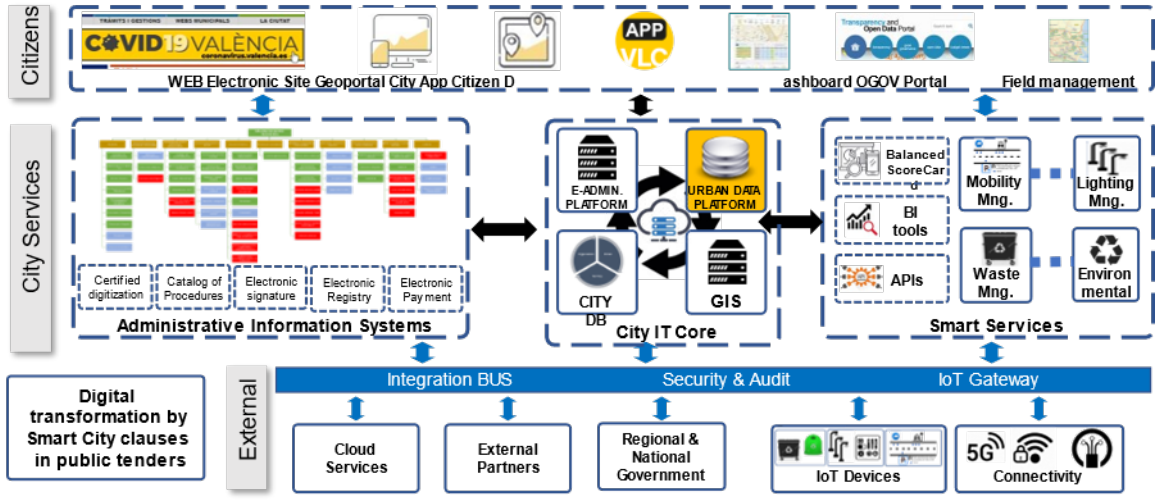


The main element of the smart city strategy was the public urban platform contract structured in two lots. The first provided the city of Valencia with an integrated management platform for the city, and the second created a project office to support the technological modernization of municipal services and the construction of solutions for citizens on the urban platform.

The VLCi platform, designed to act as a nucleus for the efficient management of the city, seeks to achieve a more intelligent, sustainable and transparent management system that benefits citizens, companies and the Administration. It offers a layer for the collection of information from IoT devices, information systems of the city and its socio-economic environment. It forms the hub of the information system of the city relying on Big Data with a context manager to facilitate solutions between domains and a series of solutions for citizens and municipal managers based on dashboards.

Figure 39, shows a high-level description of city IT components, the role of the urban data platform (VLCi platform) and its relationship with smart city challenges.

Figure 39: Valencia IT challenges, Smart City Framework



Throughout the process, the urban platform has been seen as a catalyst for synergies with the city's innovative ecosystem. Since its inception, it was an inherent part of the Local Innovation Pact, maintained over time in Valencia Tech City and in the Missions. It was connected intrinsically with the economic, social and academic environment to promote and retain talent, facilitate entrepreneurship, stability and specialization of SMEs, as well as in promoting the transfer of knowledge to the industrial fabric and in guiding research towards special needs.

The process was marked with a willingness to share, collaborate and learn together in building city networks, as well as strong commitments to national and international norms and standards in Smart and Sustainable Cities:

- Spanish Network of Smart Cities. Working group coordinator.
- Red Innpulso, innovation network in cities, member of the management team.
- Committee of Aenor CTN / 178-Smart Cities. Sub-Committee Chairman.
- United for Smart and Sustainable Cities (U4SSC). Thematic group coordinator.
- Member of the Open Agile on Smart Cities.
- Member of the European Association for the Innovation of Smart Cities and Communities.

It should be noted that in 2015, the city of Valencia obtained the ISO 37120 certification "Sustainable development in cities", as well as "Indicators of urban services and quality of life" at the platinum level. In 2018, the city received the U4SSC certification "Key performance indicators for smart cities to assess the achievement of the sustainable development goals".

These KPIs allow city managers to analyse the evolution of key aspects of the city, as well as to compare themselves with others.

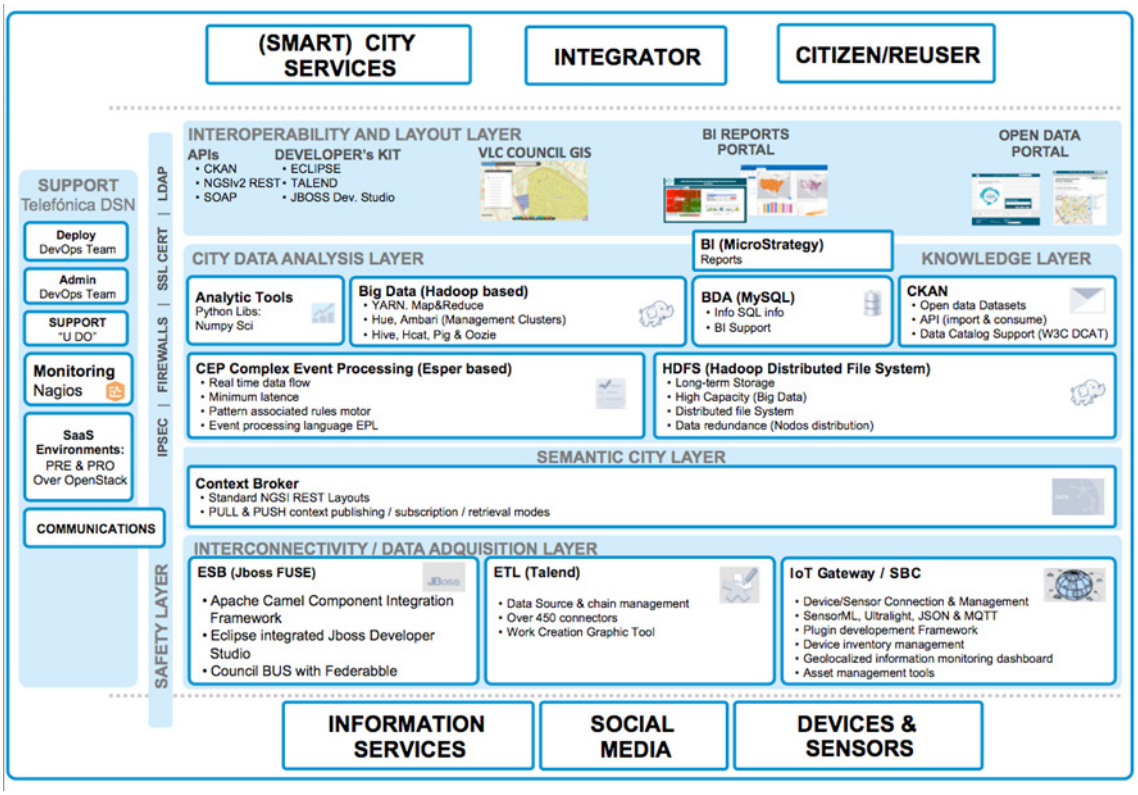
10.2 Technological architecture of the urban platform

The public contract for urban platforms defined a set of general characteristics: an open platform based on open technologies and standards, focused on the future Internet approach with requirements for security, robustness, horizontality and adaptability, and an architecture based on layers: management, integration and interoperability, Data Processing, Management and Exploitation, Business Support, Application and Access. This later constituted the nucleus of the UNE 178104 standard for integrated city management architecture "Smart Cities: Interoperability requirements for a smart city platform".

The winning bid used the Thinking City platform based on the European open-source standard FIWARE.[14]

The VLCi city platform has mechanisms for the acquisition and processing of information through the IoT Agents, which collect all the observations that come from the devices and transform them into NGSI events that support the UL2.0, JSON protocols, HTTP and MQTT, as well as the Context Agent, which is responsible for retrieving, maintaining and entering context information within the VLCi platform. Concrete evidence of this model is illustrated in the following figure:

Figure 40: Current Valencia Smart City Platform



The VLCi platform has data storage and distribution mechanisms with Big Data capabilities. This information is made accessible through the Business Intelligence system (MicroStrategy) or open-data portals.

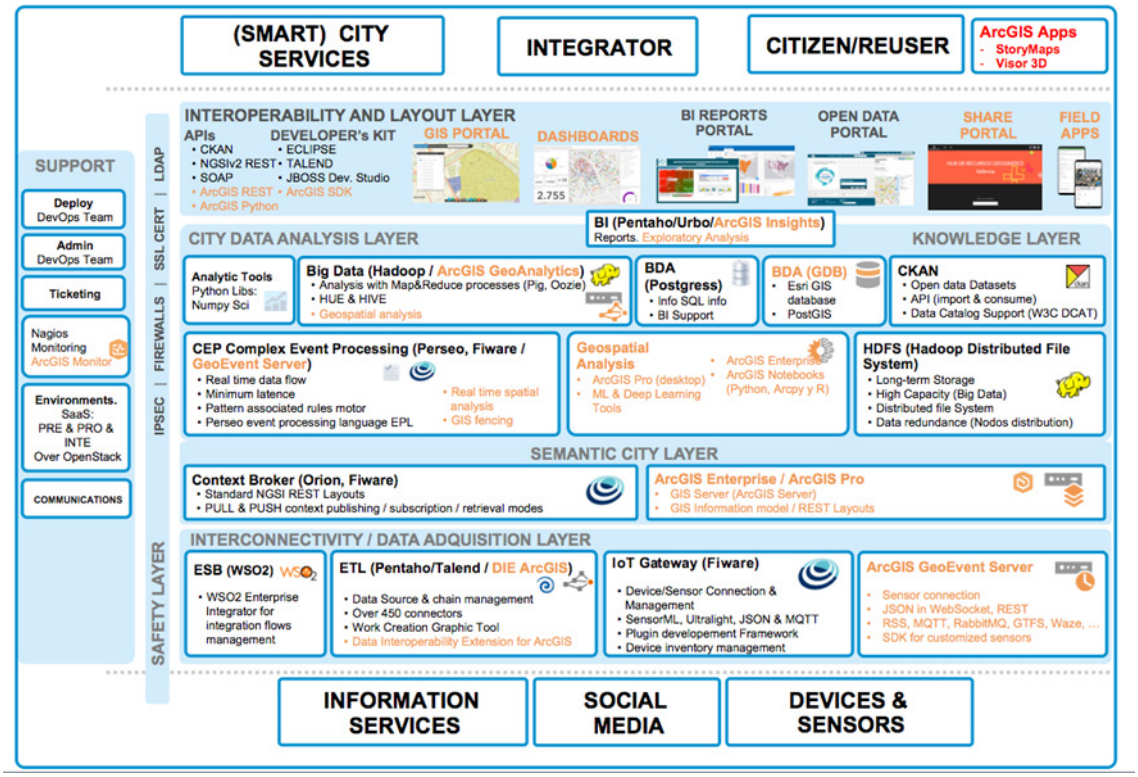
The platform is organized in a modular way, enabling the replication of functional blocks and the expansion of data acquisition, processing and storage capabilities.

The VLCi platform has the following components: IoT device management portal, platform management portal, NGSI data adapter, data analysis and visualization tools and various servers for running data integration and loading tools with external systems (ETL). The platform is protected using components for user authentication, systems monitoring and auditing.

One of the key aspects of the VLCi platform is the exploitation of standardized data within the FIWARE framework. These harmonized models allow information to be represented homogeneously, facilitating interoperability with other systems and platforms in the city.

In the coming months, the architecture of the platform will evolve, enabling the urban platform to converge technologically with the geographic information system. The following figure shows the vision:

Figure 41: New vision of the VLCi platform



10.3 Set of operational IT solutions for integrated city management

The city platform serves as a technological base for the transformation of municipal services. Currently, 25 projects provide value-added services to citizens and those responsible for the services of the municipal corporation with relevant information supporting decision-making.

Valencia has a municipal geographic information system connected to the city platform that provides information on existing resources in the city with 68 municipal services reporting data to more than 350 layers of geographic information. Most of this information is available to citizens through the Geoportal website.

The information systems of the different municipal services have been integrated into the city platform. This allows data of interest for each service to be obtained, which will be managed in a common repository, along with information on performance (KPI) for self-evaluation of the municipal service. All this information is displayed on the dashboards for internal use by municipal managers.

The Unified and Economic Management Panels facilitate consulting georeferenced data, and more than 750 existing indicators and information of interest such as the management of current expenses, the average payment period to suppliers and pending administrative tasks, all of them broken down by municipal services and areas.

The re-use of the open data of the city platform and the municipal geographic information system has facilitated the development of a scorecard of the state of the city in real time, called "Valencia Al Minut".

The city platform has made it possible to make a Transparency and Open Data portal available to citizens and companies in which more than 130 data sets are published in 800 different formats, accessible through the web or APIs and CKAN openings for third parties.

The AppValencia, connected to the city platform, integrates all the information related to the city and facilitates the completion of administrative procedures.

During the COVID-19 crisis, a new municipal website[15] was developed and published through which citizens can receive information on any issue related to the pandemic.

The "Impulso VLCi" initiative, which includes 17 projects – some of which are already operational – will provide the city with new services such as real-time monitoring of the occupancy of parking spaces with reduced mobility (PRM), loading and unloading zones and taxi stands, and will also monitor the real-time filling of containers, the intelligent management of public lighting, the deployment of environmental stations in the city's EMT bus fleet, the deployment of noise sensors in problem areas, fast-charging stations for electric vehicles with their respective occupancy sensors, and regulated parking management.

The "Connecta VLCi" proposal also includes the deployment of sensors and actuators to monitor and control 194 municipal management buildings and the development of new services for citizens such as a dynamic content display system for museums, a platform for environmental awareness for the educational community and an app for the reservation of sports facilities. It also considers the connection of the city platform with systems of other public-private entities (e.g., ADIF, AENA) that facilitate the exchange of information of mutual interest.

10.4 Governance

The Valencia City Council, in line with its corporate strategy for digital transformation, created the Smart City Office on 16 February 2018 under the Delegation of Digital Agenda and Electronic Administration of the City Council with the following responsibilities:

1. Advise, guide and report on the smart city model and the different municipal strategies in the fields of smart city and connectivity.
2. Coordinate and direct the analysis, design and management of smart city projects.
3. Management of Internet of Things-related projects, the introduction of ICT in public services and digital transformation.
4. Design, control and maintenance of the technological architecture that guarantees connectivity with citizens.

5 Management and responsibility of VLCi, the Integrated City Management Platform.

6 Direction and coordination of the integration and functional compatibility of projects with the smart city IT systems and technologies.

7 Collaboration in the management and coordination of R&D financing initiatives and programmes in the smart city environment.

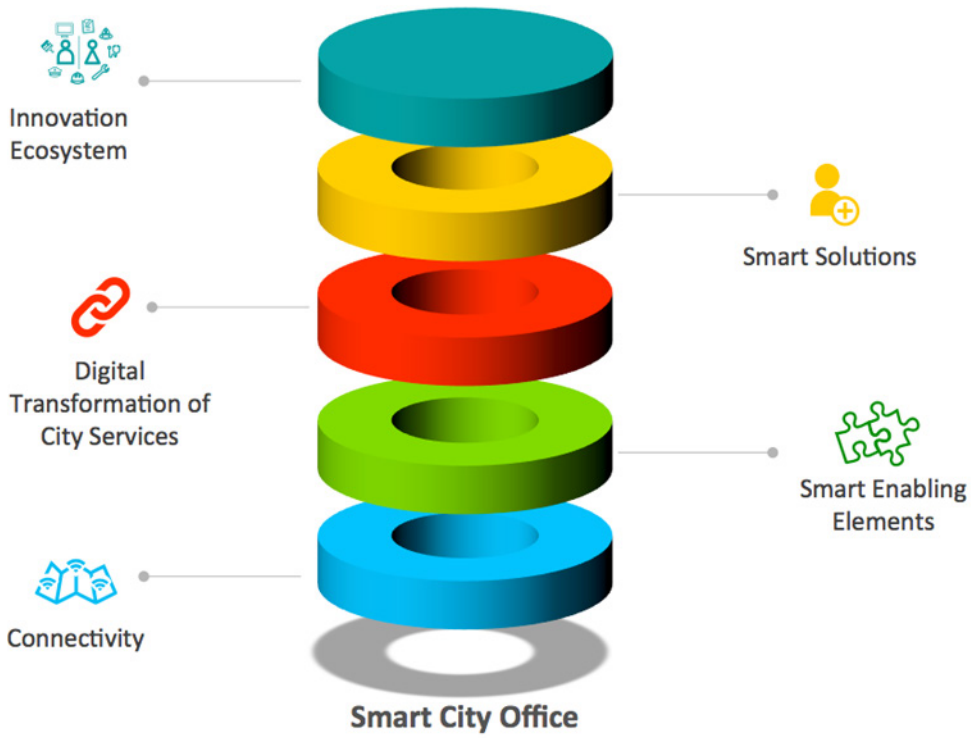
8 Preparation of methodologies and work regulations related to the introduction of ICT in public services.

9 Coordination of the technical staff in the execution of the projects and their subsequent utilization, maintenance and evolution of the operation.

10 Training in new products and technologies to keep up with ongoing developments and evolution.

The Smart City Office is made up of an interdisciplinary team of people (currently 15) who manage the administrative, strategic and technical aspects, and are in charge of the development and control of all the all responsibilities of the Office. The current project team is subdivided into an integration team of eight people and a management and strategy team of seven people. The smart areas of action are:

Figure 42: Smart action areas of the smart city office



A smart city requires quality connectivity in the largest areas of its territory to offer smart services to citizens, as well as to municipal services and municipal contractors. A strategy for connectivity

and another for IoT deployment have been developed to coordinate the implementation of the infrastructure.

Smart enablers, as well as smart solutions in production, have been explained above.

One of the Office's main lines of action is the digital transformation of municipal services and the integration of these technologies and their associated information on the urban platform.

The city of Valencia is managing the digital transformation mainly through the introduction of smart clauses in the technical specification sheets of public contracts. These clauses identify the data and information, and establish the semantic and frequency integration contracts for the urban platform based on open standards.

The induction of the information systems of the current municipal services is carried out employing a technological and data model audit, integrating the information through data transformation and integration tools. The Valencia City Council has integrated a large part of the municipal services from which data are collected in almost real time from sensors deployed by the city or from KPIs that monitor services.

An important aspect of the urban platform is its fundamental role in driving the evolution towards a knowledge economy. Entrepreneurs, researchers, journalists and society in general also make use of the data and the information based on the different degrees of access provided by the platform.

10.5 Economic Sustainability

One of the main aspects of the study in defining the smart city strategy in 2013 was the feasibility and economic sustainability study of the urban platform, as well as the legal-administrative formula for its operation.

Financing options for the platform were addressed based on contributions from large city service contracts (including mobility, solid waste, street cleaning and lighting) due to the advantages and reduction in costs accruing from the use of a common platform.

Given the administrative complexity of this solution in the Spanish public procurement system, a firm commitment was made to have an urban platform with its financing coming from a specific public contract to develop the data infrastructure of the city.

The necessary financial resources were provided from the municipal budget, in particular through a four-year public tender for EUR 4.2 million (VAT included), which includes the use of the Cloud City platform for EUR 1.6 million (VAT included), as well as a project office responsible for the tasks of operating the platform and supporting the transformation of the municipal services for EUR 2.3 million (VAT included).

The investment of around EUR 1 million per year in the city platform has provided a huge return on investment. The cost reduction achieved by using the platform in different important service contracts (e.g., mobility, telephony) has already doubled the annual investment in the platform. Additionally, the productivity of the urban platform has been a fundamental factor in contributing to the receipt of external financing in competitive bidding.

In 2016, Valencia City Council received a grant of EUR 4.2 million from the public entity Red.es for the development of 17 Smart City projects (IMPULSO VLCi), the existence of a city platform being a positive evaluation criterion. The application and management of the assistance were carried out by a team from the Smart City Office.

In 2017, Valencia City Council received aid of EUR 1.6 million from MAtchUP, the European Union-funded Smart Cities and Communities lighthouse programme for the development of different projects arising from a positive evaluation of the city platform.

In 2019, Valencia City Council received additional aid of EUR 2.5 million from the public entity Red.es to integrate 194 municipal buildings into the municipal platform. The finances were managed by the Smart City Office team and the technical office of the project.

Obtaining aid in previous projects can be considered as quantifiable performance. Non-quantifiable returns are linked to better efficiency and management in municipal services.

Currently, the monetization strategy of the information contained in the platform has not been developed. The information provided to universities and research centres has been free of charge and through confidentiality agreements with these institutions.

The improvements in strategic and operational decisions that are delivered by the dashboards in municipal areas are not valued, neither is the resulting reduction in administrative overheads.

Enhanced production by local enterprises as an outcome of API data generated by the platform have also not been accorded a monetary value and neither have endowments and funding of research projects provided by the platform to university departments aimed at improving their research capacity.

In summary, it is clear that investment in the city platform has been wise and sustainable, bringing direct and indirect benefits to the city, as well as tangible and intangible benefits for citizens and the socio-economic environment.

10.6 Key Factors and Barriers to Implementation

The key success factor for the implementation of a smart city strategy in the city is the conviction among policy-makers of the importance of data as critical 21st-century infrastructure needed by a city to move forwards in a robust and sustainable way.

It is based on the conviction that an urban platform should not remain in the research or proof-of-concept domain but is a fundamental element of integrated city management and that its implementation requires a public contract that supports its consolidation over time with its own support team.

The technology on which the majority of non-administrative city services are deployed is usually offered by large contractors. As a result, municipal services have had little access to data and no knowledge and control of ICT systems and, therefore, no capacity to integrate it into the city's management practices.

Among the main barriers to this consolidation has been the management of change that requires contractual evolution and the adaptation to new organizational and technological processes needed to manage cross-sectoral services on an urban platform. It is very important to have officials responsible for this, with support from the government team.

As soon as city services begin to use the services and solutions offered by the urban platform and obtain adequate support in their technological transformation, a turning point occurs in the structure of the urban platform and the smart city office as an element in the digital transformation of the city.

The effect of articulating the use of the platform and the support project team on a major public tender prompted the main companies to improve their solutions and strengthen their commitment to this sector. In the case of Valencia, the public tender was won by the Telefónica company, which has become a benchmark for these types of services in the sector, and the collaboration between this large company and the city has produced a multitude of synergies and benefits for both entities.

Membership in smart city networks, the exchange of good and bad experiences in this area, and the commitment to standards have also contributed to the success.

10.7 Stakeholders' involvement

The choice of Telefónica's Thinking City platform based on the FIWARE open ecosystem is backed by robust technological support, which guarantees technological evolution over time.

Thanks to an open architecture and the clarity of smart clauses in a standardized connection procedure, municipal service management companies can send automated information on the operation of the service, as well as on the fulfilment of their contract to the city platform.

With support from the European MatchUP project, the Polytechnic University of Valencia uses the city platform to develop different APIs and flows through the city's systems, exploiting digital technology sensors, mobile applications and social networks. In future, all new developments will be provided as open APIs of value-added urban services that can be seen as building blocks to improve city management. The data generated by the project will be published as open data, taking into account privacy and security.

In addition, different research groups are using the data provided by the city platform to develop their own mobility and environmental projects.

All information is a click away for citizens on the city's Open Data Portal, with more than 100 data sets and more than 700 distributions. Likewise, the Transparency Portal provides people with all the pertinent information about the COVID-19 crisis.

The APIs offer programmers the ability to re-use any set of the catalogue data.

Lastly, the existence of the urban platform has facilitated financing for national and European competitive simultaneity projects, and their integration into the platform is a requirement for these projects. The most important projects in which the integration in the VLCi platform has already started are MatchUp, Growgreen, IMPULSO VLCi and CONNECTA VLCi.

Endnotes

1 This document has been published for informational purposes only. U4SSC and its partners cannot be held responsible for the content provided by the city representatives and other stakeholders.

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5 http://repositoriodigital.corfo.cl/xmlui/handle/11373/10242

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