# MAtchUP

## D2.23: Urban platform Integration and Interoperability in Valencia (2nd version)

***WP 2, T2.6***

***Date of document***

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**Technical References**

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[1] PU = Public
PP = Restricted to other programme participants (including the Commission Services)
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## Table of Content

## List of Tables



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## List of Figures



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## Abbreviations and Acronyms

| Acronym | Description |
|---|---|
| CEP | Complex Event Processing |
| API | Application Programming Interface |
| BI | Business Intelligence |
| CEP | Complex Event Processing |
| CKAN | Comprehensive Knowledge Archive Network |
| CSW | Catalogue Services for the Web |
| DCAT-AP | Data Catalogue vocabulary – Application Profile |
| DPO | Data Protection Officer |
| EMT | Municipal Transport Company (Empresa Municipal de Transporte) |
| ESB | Enterprise Service Bus |
| EIP | European Innovation Partnership |
| ETL | Extract, Transform and Load |
| EV | Electric Vehicle |
| GDPR | EU General Data Protection Regulation |
| HTTP | HyperText Transfer Protocol |
| ICT | Information and Communications Technology |
| IDM | Identity Manager |
| IDABC | Interoperable Delivery of European eGovernment Services to public Administrations, Businesses and Citizens |
| IoT | Internet of Things |
| JSON | JavaScript Object Notation |
| KPI | Key Performance Indicator |
| LOPD | Organic Law on the Protection of Personal Data |
| NGO | Non-governmental organization |
| NGSI | Next Generation Service Interfaces |
| OMA | Open Mobile Alliance |
| PII | Personally Identifiable Information |
| POI | Point of Interest |
| REST | Representational State Transfer |
| RT | Real Time |
| SQL | Structured Query Language |
| STH | Short-Term Historic |
| UK | United Kingdom |
| VLCi | Valencia Urban Platform |

# 1 Abstract

This deliverable is part of Task 2.6. Urban Platform developments. This task is in charge of developing a number of services to improve city operation, decision-making services, and citizen engagement to ensure the interaction between the city of Valencia and its citizens.

When integrating new services on top of the Urban Platform in Valencia (VLCi), it becomes fundamental to deal with the need of studying the adaptations and extensions required for the existing VLCi urban platform with regard to publish open Data, open APIs and data integration from the actions to be deployed in the city interventions. Basically, this is reported in deliverable D2.21. With this in mind, these new services must guarantee interoperability between the different agents involved.

For that purpose, a definition of an interoperability test plan for Valencia is needed, to be established from a harmonised approach in the three demos. From this common definition, the next step is testing the new modules developed under the top of the Urban Platform, ensuring that they interoperate following the open concept in the urban platforms.

Moreover, it will be necessary to publish non-sensible and anonymized data for being queried and explored by citizens and developers willing to make use of it in order to create innovative services for the city. Therefore, it is worth noting that privacy and security aspects should be taken into account, paying especial attention to the new European General Data Protection Regulation (GDPR).

As far as the cities in the project share a common objective, this deliverable D2.23 shares a common structure with the analogous deliverables of WP3, which is D3.23, and WP4, which is D4.23. Furthermore, these deliverables are due in M24 as a second version of the documents. They will be completed and extended as the project advances and new outcomes are obtained, resulting in a final deliverable in M36.

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# 2 Introduction

## 2.1 Purpose

The objective of this deliverable is to report on the current state of concept and development of the urban platform integration and interoperability in Valencia demo site.

From this perspective, the first thing to do is to define the concept of interoperability and differentiate between vertical and horizontal interoperability. Actually, interoperability facilitates communication among modules. Hence, the modules of the architecture of a Smart City are defined, paying especial attention to the interaction and interoperability among them.

It is also important to define data models, since they are the schemes that must be followed for the exchange of data from one module to another. The fact of having a robust and well-defined data model will maximize the interoperability between the components of the system. Moreover, the catalog of datasets used in the project is also defined.

Additionally, the interoperability performance must be assessed in order to confirm that the functionality of the new services is preserved. For this purpose, interoperability tests for VLCi Platform are defined in a way that they can assure the full interoperability of its modules.

Finally, security and privacy issues are addressed, with special emphasis in the new European General Data Protection Regulation (GDPR), in order to deal with how security and privacy will be tackled. In the last version, this deliverable will focus also on the need to evaluate security mechanisms in the application endpoints, to control the City Platform access, and to study security strategies, such as encrypted communications or anonymity treatment, among others.

## 2.2 Contribution of partners

The following Table 1 depicts the main contributions from participant partners in the development of this deliverable.

| Participant short name | Contributions |
|---|---|
| UPV | Content |
| VAL | Revision |
| LNV | Comments about ICT actions |
| ITE | Comments about Energy actions |
| ETRA | Comments about Mobility actions |

**Table 1. Contribution of partners**

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# 3 Interoperability definition

In general, interoperability refers to the capability of two or more networks, systems, devices, applications, or components to exchange and readily use information securely, effectively, and with little or no inconvenience to the user. This is the common definition that can be found in the literature. Next sections will focus on applying this definition to the context of Smart Cities, and more precisely, to the context of MAtchUP project.

## 3.1 Interoperability in the Smart City context

The concept of Urban Platforms for the European Innovation Partnership (EIP) on Smart Cities and Communities and, more precisely, for the Urban Platforms group of the Integrated Infrastructure Action Cluster, is defined as *solutions that help cities digitalize and manage their services*. Moreover, these platforms are the core building block in which the cities manage all their data. Thus, services and data, together with interoperability, security and privacy are the essential concepts to be tackled by the urban platforms. For the EIP, when it comes to interoperability, the priority is on *ensuring the vertical interoperability* (development of reusable and interoperable services) instead of prioritizing the horizontal interoperability (between platforms). Thus, to maximize the potential replicability and scalability of the developments on top of the urban platforms vendor lock-in solutions must be avoided, as interoperability and scalability are hampered with these locked approaches.

In this sense, in MAtchUP Project there are also two kinds of interoperability: vertical and horizontal. Following the EIP suggestions, the project will focus on vertical interoperability especially. Vertical interoperability mainly occurs when the Smart City solutions share data. In other words, the services the city usually offers are fragmented for each sector of energy, mobility, ICT, among others. For instance, the public transport service that is part of the mobility sector and the associated data is not shared with other verticals. All those services from different sectors generate data and information that have different providers and, therefore, an automatic liaison of the different services within the same city becomes necessary.

In contrast, horizontal interoperability occurs when data is exchanged between different smart cities, i.e. a city offers similar services, such as the domestic waste management service. This service is also offered in another city and there is an exchange of information between solutions in the cities.

Figure 1 and Figure 2 graphically represent both types of interoperability, which are present in the project:

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**Figure 1. Vertical Interoperability**

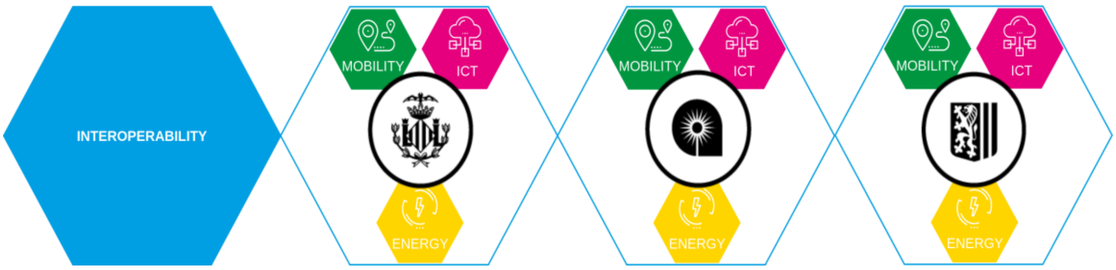


**Figure 2. Horizontal Interoperability**

## 3.2 State of the art and related projects

One of the challenges faced by the project is to process and visualize data from heterogeneous systems and environments, such as sensors or the owner platforms involved. All these systems must be integrated in a common platform and, for this purpose, it becomes necessary to guarantee the interoperability of data.

This common platform, called the Urban Platform, combines Internet of Things (IoT) with cloud computing, among other technologies, to ensure interoperability, allowing the aggregation of data from different systems in a common and open database.

The Urban Platform of Valencia has been developed using FIWARE, an open source platform founded by the European Union, which is characterized by obtaining, storing, processing and displaying relevant information from different sources in real time or through batch processes.

In the context of Smart Cities, information is obtained from elements of the city, such as street lamps or buses, which use different protocols to send information. FIWARE is in charge of translating all the information gathered from different sources into a common language, the Next Generation Services Interface (NGSI). NGSI is a protocol developed by Open Mobile Alliance (OMA) that manages contextual information about

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entities (elements of the city such as streetlights or buses) and its objective is the standardization of interfaces in a common language.

Moreover, the use of FIWARE allows to replicate and scale this platform in other cities without major adaptation efforts, since FIWARE is a standardized solution and is mainly based on components called Generic Enablers that facilitate interoperability.

Besides the FIWARE project, recently there have been some new projects related to interoperability, such as the INTER-IoT project [1], which is a European project framed in Horizon 2020 programme with the aim to provide an interoperable framework architecture for seamless integration of different IoT architectures present in different application domains. In this project, interoperability will be provided at different levels: device, network, middleware, services and data.

Another project related to interoperability is the i-SCOPE project (Interoperable Smart City services through an Open Platform for urban Ecosystems) [2], which focuses on delivering an open platform on top of which it develops, within different domains, three smart city services.

## 3.3 Regulatory framework for interoperability

In order to eliminate the barriers that are generated when integrating different heterogeneous systems and to create a common platform to guarantee interoperability, a regulatory framework is needed, so that it defines standards to be applied and a set of principles to be met.

### 3.3.1 National interoperability standards

In Spain, a huge effort has been made in recent years to digitize public institutions and to commit to transparency. Each region has its own information systems and communication between them is necessary. This fact has caused the need to create a regulatory framework on interoperability standards in order to be able to exchange information between the Spanish municipal and regional entities.

At the beginning of 2010, the Royal Decree 4/2010 for the National Scheme of Interoperability for Government was published, regulating the National Interoperability Scheme in the field of Electronic Administration of Spanish municipal and regional entities. This decree describes the term interoperability as the capacity of information systems and procedures to share data and enable the exchange of information and knowledge between them. It also indicates that interoperability for the development of services offered by public administrations was impractical.

However, it is worth highlighting the fact that this decree is limited to establish the criteria, recommendations and principles that allow the development of interoperability of public administrations from a global and not fragmentary perspective. Furthermore, it is also important to note that the National Interoperability Scheme addresses the organizational, semantic and technical aspects of interoperability, as well as the simplification and propagation of it.

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Prior to this decree, the interoperability term was mentioned in Law 11/2007 of June 2007. This law regulates the electronic access of citizens to public services and refers to interoperability as one of the mandatory aspects of regulation by the Spanish government. In addition, it was based on the principle of cooperation and became one of the protagonists of the necessary impulse of the electronic administration in public entities. This law also indicates the fact of ensuring interoperability and urges the municipal entities to take into account interoperability to develop their information systems and communicate with other entities.

### 3.3.2 International interoperability standards

In the European Union there is a European Framework for Interoperability, developed by the Community program called Interoperable Delivery of European eGovernment Services to Public Administrations, Businesses and Citizens (IDABC) [3]. In addition, in September 2009, Decision No 922/2009 of the European Parliament and of the Council was published, related to interoperability solutions for European public administrations, to action plans on e-government on interoperability, and to the Community policy of sharing, reusing and collaborating.

On the other hand, interoperability is possible thanks to the existence of open standards. Open standards are publicly available formats or specifications, regardless any individual provider are free of legal or technical clauses that limit their use. Some examples of open standards are the following:

- DCAT-AP: The DCAT Application profile for data portals in Europe (DCAT-AP) is a specification based on the Data Catalogue vocabulary (DCAT) for describing public sector datasets in Europe. Its basic use case is to enable cross-data portal search for data sets and make public sector data better searchable across borders and sectors. This can be achieved by the exchange of descriptions of datasets among data portals.

- CSW (Catalogue Services for the Web): It is a standard defined by the Open Geospatial Consortium for publishing catalogue records for geospatial data.

- INSPIRE: The EU INSPIRE Directive aims to create a Europe-wide infrastructure for public sector spatial information. It specifies formats and discovery services that public authorities must use for publishing spatial data.

- REST (Representational State Transfer): It is a standard interface for web applications. It appeared in the year 2000 and it is usually used to develop APIs. For example, the common NGSI language used in FIWARE provides a REST API via HTTP for obtaining data or performing operations on data stored in FIWARE.

- Schema.org [4]: It is a collaborative, community activity with a mission to create, maintain, and promote schemas for structured data on the Internet. The schemes have a specific standard vocabulary for different entities. For example, the Place scheme can be used in a city for fixed places such as squares or parks.

# 4 Smart City modules definition

## 4.1 Requirements for Urban Platform Integration and Interoperability

Vertical interoperability could be achieved through endpoints, which allow the communication between layers, modules or services. In the case of Valencia Urban Platform, several different endpoints are used depending on the nature of the data to be integrated, since the nature of the available data is heterogeneous.

Some sources of data integration are:

- Measurements from sensors of different nature, integrated through the IoT Agent component.

- Processed measurements from external platforms, integrated through the Context Broker.

- Information and processed results from external portals, integrated through the ETL component or a batch process.

The general view of the Valencia Urban Platform (VLCi) can be seen in Figure 3. The different modules used in the project are explained in the next sections.

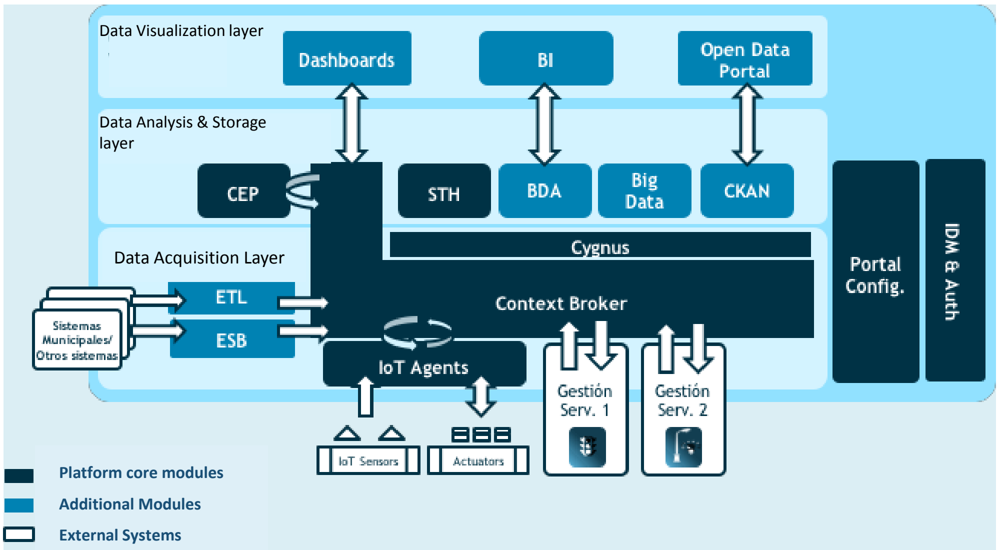


**Figure 3. General building blocks of Valencia Urban Platform**

## 4.2 Core modules

*Orion Context Broker*

This is the core component in charge of recovering, maintaining and introducing context information into the platform. In order to communicate with this component, the use the NGSi interface must be necessary.

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*Cygnus*

This component subscribes to Orion notifications, and is responsible for processing the data sent by the Orion Context Broker and adapting them to the different types of storage available in the platform, such as MySQL, MongoDB, CKAN or Hadoop.

*STH (Short-Term Historic)*

This component is in charge of storing the data sent to the Orion Context Broker and allows the recovery of data in both the form of raw data and aggregated data. It can also be treated as an output module.

*IDM (Identity Manager) and AUTH*

This is a security component and is responsible for managing the identity, authentication and authorization for those agents interacting with the platform.

*Administration and configuration portal*

This is a web portal that can be used to operate the platform and perform operations, such as manage services, users, devices, entities, and even subscriptions to notifications.

*CEP (Complex Event Processing)*

This component analyses the data coming from events or situations in real time, processes them and then sends a response according to those situations.

## 4.3 Input modules

*IoT Agents*

Sensors send information through IoT Agents, which are in charge of translating the data using FIWARE models.

*ETL (Extract, Transform and Load) and ESB (Enterprise Service Bus)*

These elements are responsible for obtaining information from external sources that do not have compatible formats with the Orion Context Broker. ETL interface is used for batch processing while ESB interface is commonly used for real-time processing.

It is worth mentioning that external sources can push information to the platform using NGSI through the Orion Context Broker directly.

## 4.4 Output modules

*ADB (Analytic Database)*

This is a database where long term information can be stored and requested later.

*BI (Business Intelligence)*

This element is a tool to analyse the historical data stored in ADB.

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*Big Data (Hadoop)*

This element is responsible for storing the bulk data sent to the Orion Context Broker and has the ability to perform processing operations on large datasets.

*CKAN (Open Data Portal)*

This element is a tool for open data web portals. It facilitates the management and publication of data collections.

In addition, dashboards can be created to display information about measurements and KPIs stored or generated in the Urban Platform.

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# 5 Data modelling

Data modelling is one of the most important phases in a project and determines how to structure, organize and store the data, to later exploit and use them from a database.

A database is a set of data stored in external memory that are organized by a data structure defined in the data modelling and that can be used at the same time by different organizations or users.

There are many methodologies for the creation of a database. The first generation involved the hierarchical data modelling and the network data modelling, followed by the second generation, which was the relational data modelling. Latter was evolved to the popular modelling of entity-relationship data, providing a data model that represents the real world in a more faithful way. Currently, the most widespread is the non-relational data modelling, which was born from the need to overcome the limitations of relational data models when large amounts of data were available, usually in an unstructured way.

In hierarchical modelling, the data is structured in the form of a tree with parent-child relationships (each parent can have many children but each child has only one parent) whereas in network modelling, the data is structured in a collection of records or a set of fields and attributes connected to each other by means of links (a child node in the network structure can have more than one parent node). However, in relational modelling, the data are structured in the form of entities and tables, with attributes and relationships between entities. Finally, in non-relational modelling, the data are structured in key-value pairs.

The non-relational data model will be used in the project, since a large amount of data is available and most of this data is not structured. This way, it will also have to support the system being scalable. The data that must be modelled will be that generated by the city. This data is of different nature and is generated both in real time and in batch mode. In addition, some data will be saved for analysis in real time and some other data will be saved for historical data conservation and for the open data catalogue.

In this section, it will be explained how the data generated by the city is represented following a standard and interoperable data model that uses ontologies and semantic annotations in the data that can be reused by other cities with similar characteristics.

## 5.1 Urban Platform Data Models

Valencia demo uses FIWARE data models [5], which are interoperable data models for storing and exchanging data. These data models have been harmonized to enable data portability and each data model defines the minimal set of information about elements of the city, reusing schemas in order to support interoperability.

In the design phase of the datasets, FIWARE data models will be taken into account, so the new datasets created will be fit or adapted to existing standard FIWARE datasets models previously studied.

FIWARE data models consists of twelve basic data models (although new additional data models are currently being developed), where each one has a set of particular

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attributes and relationships, depending on the city element. These main models are shown below:

**ALERTS**

Alerts Events related to risk or warning conditions which require action taking.

This entity models an alert and could be used to send alerts related to traffic jam, accidents, weather conditions, high level of pollutants and so on. The purpose of the model is to support the generation of notifications for a user or trigger other actions, based on such alerts.

An alert is generated by a specific situation. The main features of an alert are that it is not predictable and it is not a recurrent data. That means that an alert could be an accident or a high level of pollutants measure, additionally it could be the fall down of a patient or a car driving in the opposite direction.

**PARKS & GARDENS**

Data models intended to make an efficient, effective and sustainable management of green areas.

These data models are intended to model parks, gardens and related green spaces in a city. The main entity types identified are:

- *Park*. A park is an area of open space provided for recreational use, usually designed and in semi-natural state with grassy areas, trees and bushes. Parks are often but not always municipal. Typically open to the public, but may be fenced off, and may be temporarily closed, e.g. at night time. Schema.org already provides an entity type for this purpose which can be reused.
- *Garden*. A garden is a distinguishable planned space, usually outdoors, set aside for the display, cultivation, and enjoyment of plants and other forms of nature. A garden can incorporate both natural and man-made materials. Western gardens are almost universally based on plants. A garden can also be a part of a park and open to the public. A garden can be divided into several smaller parts, named flower beds.
- *FlowerBed*. A garden plot in which flowers (or other plants) are grown. Usually you will find flower beds in parks, gardens, pedestrian areas or at big highway interchanges.
- *GreenspaceRecord*. This entity contains a harmonised description of the conditions recorded on a particular area or point inside a garden or related green space. Such record can be associated to a garden, to a specific flower bed, etc.

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Although this FIWARE model is being used in VLCi, it is not planned to be used in this specific project.

**ENVIRONMENT**

Enable to monitor air quality and other environmental conditions for a healthier living.

These data models describe the main entities involved with smart applications that deal with environmental issues. The main entities identified are:

- *AeroAllergenObserved*. It describes aero allergens observed at a given location and related overall allergen risk.
- *AirQualityObserved*. It represents an observation of air quality conditions at a certain place and time.
- *WaterQualityObserved*. Allows to capture all the parameters involved in Water Quality scenarios, allowing to deal with different scenarios: rivers and lakes; reservoirs like dams, cisterns, impoundments; sea locations; swimming pools or fountains.
- *NoiseLevelObserved*. It represents an observation of those parameters that estimate noise pressure levels at a certain place and time.

Although this FIWARE model is being used in VLCi, it is not planned to be used in this specific project.

**POINT OF INTEREST**

Specific point locations that someone may find useful or interesting. For instance, weather stations, touristic landmarks, etc.

These data models allow to model points of interest and related entity types:

- *PointOfInterest*. A harmonised geographic description of a point of interest. Point of interest, or POI, is a specific point location that someone may find useful or interesting.
- *Beach*. A harmonised description of a beach. It is a loose geological landform along the coast or along another body of water consisting of sand, gravel, shingle, pebbles, cobblestones or sometimes shell fragments, etc.
- *Museum*. A harmonised description of a museum. It is an institution which has exhibitions on scientific, historical, cultural topics. Typically open to the public as a tourist attraction. May be more heavily involved in acquiring, conserving or researching such topics.

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Although this FIWARE model is being used in VLCi, it is not planned to be used in this specific project.

**CIVIC ISSUE TRACKING**

Data models for civic issue tracking interoperable with the de-facto standard Open311.

These data models allow to perform civic issue tracking. They have been designed with a view to enabling trivial interoperability between FIWARE NGSI-10 and Open311 [6]. The main entities identified are:

- *Open311:ServiceType*. A type of service a citizen can request. It encompasses data from the Open 311 GET Service List and GET Service Definition.
- *Open311:ServiceRequest*. A specific service request (of a service type) made by a citizen.

This FIWARE model is not planned to be used in this specific project.

**STREET LIGHTING**

Modeling street lights and all their controlling equipment towards energyefficient and effective urban illuminance.

Streetlights, commonly known as 'lamp-posts', are designed to make the streets safer for pedestrians and drivers. These data models are intended to model streetlights and all their controlling equipment towards energy-efficient and effective urban illuminance. It encompasses the following entity types:

- *Streetlight*. It represents a particular instance of a streetlight. A streetlight is composed by a lantern and a lamp. Such elements are mounted on a column (pole), wall or other structure.
- *StreetlightGroup*. It represents a group of streetlights being part of the same circuit and controlled together by an automated system.
- *StreetlightModel*. It represents a model of streetlight composed by a specific supporting structure model, a lantern model and a lamp model. A streetlight instance will be based on a certain streetlight model.
- *StreetlightControlCabinet*. It represents automated equipment, usually on street, typically used to control a group(s) of streetlights, i.e. one or more circuits.

This FIWARE model will be used in intervention A.27 (Smart lighting + 4000 street lamps). An example of use is shown in Figure 4.

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**Street Lighting**


```
{
  "id": "matchup-energy-streetlight:1",
  "type": "Streetlight",
  "location": {
    "type": "Point",
    "coordinates": [ -0.375436 39.474368 ]
  },
  "areaServed": "City center",
  "status": "ok",
  "refStreetlightGroup": "streetlightgroup:G345",
  "refStreetlightModel": "streetlightmodel:STEEL_Tubular_10m",
  "circuit": "C-456-A467",
  "lanternHeight": 10,
  "locationCategory" : "centralIsland",
  "powerState": "off",
  "controllingMethod": "individual",
  "dateLastLampChange": "2018-07-08T08:02:21.753Z"
}
```


**Figure 4. Street lighting example**

**DEVICE**

IoT devices (sensors, actuators, wearables, etc.) with their characteristics

These data models allow to represent devices of different nature (IoT, mobile, wearable, etc.). It is composed by the following entity types:

- Device. A Device is an electronic apparatus designed to accomplish a particular task.
- DeviceModel. It captures the static properties common to multiple instances of a Device.

This FIWARE model will be used in interventions A.5 (Next generation of smart controls, smart controller for building and houses), A.4 (Smart meters for buildings) and A.24 (Eco-driving patterns to optimize the performance of electric buses). Examples of use are shown in Figure 5 to Figure 13.

### A.5 Next generation of smart controls

**Device Model for Smart Controller**


```
{
"id": "matchup-energy-building-model",
"type": "DeviceModel",
"category": ["meter"],
```


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```
"deviceClass": "C2",
"controlledProperty": ["electricityConsumption"],
"function": ["metering"],
"supportedProtocol": ["mqtt","lora", "gprs"],
"supportedUnits": ["HZ","KWH","KWT","VLT","AMP","KVR","P20"],
"brandName": "ETRA SmartMeter",
"modelName": "Slam",
"manufacturerName": "ETRA I+D",
"name": "SmartController model for Energy Efficiency"
}
```


**Figure 5. Device model for Smart Controller**

**Device for Smart Controller**


```
{
 "id" : "matchup-energy-building-device:0163-C1",
 "type": "Device",
    "location" : {
       "type" : "Point",
       "coordinates" : [
           2.157676,
           41.400057
       ]
   },
 "name" : "Sensor 'C1: Seu building general' Gracia",
 "description" : "Seu Districte Gracia: GENERAL RT Q1",
 "refDeviceModel": "matchup-energy-building-model:1",
 "deviceState":{
 "value":12,
 "name": "HighQualityData",
 }
 "dateLastValueReported" : "2018-05-14T04:42:54.000Z",
 "value" : {
        instantaneousFrequency: 50,
        activeEnergyImp: 0.0,
        activeEnergyExp: 0.0,
        reactiveEnergyImp:34567.678,
        reactiveEnergyExp:45678.82,
        instantaneousCurrentL1: 0.0,
        instantaneousCurrentL2: 0.0,
        instantaneousCurrentL3: 0.0,
        instantaneousVoltageL1: 0.0,
        instantaneousVoltageL2: 0.0,
        instantaneousVoltageL3: 0.0,
        instantaneousReactivePower: 0.0,
        instantaneousReactivePowerL1: 0.0,
        instantaneousReactivePowerL2: 0.0,
        instantaneousReactivePowerL3: 0.0,
```


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```
        instantaneousPowerFactorL1: 0.0,
        instantaneousPowerFactorL3: 0.0,
        instantaneousPowerFactorL3: 0.0,
        instantaneousActivePower: 0.0,
        instantaneousActivePowerL1: 0.0,
        instantaneousActivePowerL2: 0.0,
        instantaneousActivePowerL3: 0.0,
    }
   "typeDevice" : 19,
    "parent" : "matchup-energy-building-device:0163"
}
```


**Figure 6. Device for Smart Controller**

| Description properties (sensor measurements and units) |
|---|
| - dateLastValueReported: Timestamp representing the measurements included in the document. If the measurement represents a period, the timestamp should be the one at the beginning of the period.<br>- value.instantaneousFrequency: Instantaneous frequency (Hz).<br>- value.activeEnergyImp: Total active energy imported (kWh).<br>- value.activeEnergyExp: Total active energy exported (kWh).<br>- value.reactiveEnergyImp: Total reactive energy imported (kvarh).<br>- value.reactiveEnergyExp: Total reactive energy exported (kvarh).<br>- value.instantaneousCurrentL(X): Instantaneous current phase X (A)<br>- value.instantaneousVoltageL(X): Instantaneous voltage phase X (V)<br>- value.instantaneousReactivePower: Instantaneous reactive power (kvar)<br>- value.instantaneousReactivePowerL(X): Instantaneous reactive power phase X (kvar)<br>- value.instantaneousPowerFactorL(X): Instantaneous power factor phase X<br>- value.instantaneousActivePower: Instantaneous active power (kW)<br>- value.instantaneousActivePowerL(X): Instantaneous active power phase X (kW) |

**Figure 7. Smart Controller description properties**

## A.4 Smart meters for buildings

**Smart Sensor Model for Comfort Parameters**


```
{
 "id": "matchup-energy-comfort-model",
 "type": "DeviceModel",
 "category": ["sensor"],
```


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```
 "controlledProperty": ["temperature", "humidity",
 "light"],
 "function": ["sensing"],
 "supportedProtocol": ["mqtt"],
 "supportedUnits": ["CEL", "P1", "LUM"],
 "brandName": "WiTraC SmartSensor",
 "modelName": "Comfort Parameters SmartSensor",
 "manufacturerName": "WiTraC",
 "name": "SmartSensor for Comfort Parameters"
}
```


**Figure 8. Smart Sensor Model for Comfort Parameters**

**Smart Sensor Model for Energy Consumption**


```
{
 "id": "matchup-energy-consumption-model",
 "type": "DeviceModel",
 "category": ["sensor"],
 "controlledProperty": ["powerConsumption ",
 "energyConsumption ", "gasConsumption "],
 "function": ["sensing"],
 "supportedProtocol": ["mqtt"],
 "supportedUnits": ["KWT","KWH", "MTQ"],
 "brandName": "WiTraC SmartSensor",
 "modelName": "Energy Parameters SmartSensor",
 "manufacturerName": "WiTraC",
 "name": "SmartSensor for Energy Parameters"
}
```


**Figure 9. Smart Sensor for Energy Consumption**

**Smart Sensor Model for Energy Generation**


```
{
 "id": "matchup-energy-generation-model",
 "type": "DeviceModel",
 "category": ["sensor"],
 "controlledProperty": ["power", "energy"],
 "function": ["sensing"],
 "supportedProtocol": ["mqtt"],
 "supportedUnits": ["KWT", "KWH"],
 "brandName": "WiTraC SmartSensor",
 "modelName": "Energy Parameters SmartSensor",
 "manufacturerName": "WiTraC",
 "name": "SmartSensor for Energy Parameters"
}
```


**Figure 10. Smart Sensor for Energy Generation**

**Smart Sensor Model for Energy Storage**


```
{
 "id": "matchup-energy-storage-model",
 "type": "DeviceModel",
 "category": ["sensor"],
 "controlledProperty": ["power", "energy",
 "fillingLevel"],
 "function": ["sensing"],
 "supportedProtocol": ["mqtt"],
 "supportedUnits": ["KWT", "KWH", "P1"],
 "brandName": "WiTraC SmartSensor",
 "modelName": "Comfort Parameters SmartSensor",
 "manufacturerName": "WiTraC",
 "name": "SmartSensor for Energy Parameters"
}
```


**Figure 11. Smart Sensor for Energy Storage**

### A.24 Eco-driving patterns to optimize the performance of electric buses

**Smart Sensor Model for Comfort and People**


```
{
"id": "wtc:bus:comfortandpeople",
"type": "DeviceModel",
"category": ["sensor"],
"controlledProperty": ["temperature", "humidity",
"airPollution", "noiselevel", "occupancy"],
"function": ["sensing"],
"supportedProtocol": ["mqtt"],
"supportedUnits": ["CEL", "P1", "ppm", "dB", "P1"],
}
```


**Figure 12. Smart Sensor for Comfort and People**

**Smart Sensor Model for Consumption**


```
{
"id": "wtc:bus:consumption",
"type": "DeviceModel",
"category": ["sensor"],
"controlledProperty": ["power", "electricityConsumption"],
"function": ["sensing"],
"supportedProtocol": ["mqtt"],
"supportedUnits": ["KWT", "MTQ"],
}
```


**Figure 13. Smart Sensor for Consumption**

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**TRANSPORTATION**

Transportation data models for smart mobility and efficient management of municipal services.

These data models describe the main entities involved with smart applications that deal with transportation issues. This set of entities is primarily associated with the Mobility and Smart City vertical segments and related IoT applications. The main entities identified are:

- *TrafficFlowObserved*. It represents an observation about flow of traffic.
- *Road*. It contains a harmonised geographic and contextual description of a Road.
- *RoadSegment*. It contains a harmonised geographic and contextual description of a road segment.
- *Vehicle*. It represents a vehicle with all its individual characteristics.
- *VehicleModel*. It represents a model of vehicle (private vehicles, public vehicles -buses, trains, etc.-, municipal vehicles -pick up lorries, cleaning units, etc.-, special vehicles -ambulances, fire brigades, etc.), capturing its static properties such as dimensions, materials or features.

This FIWARE model will be used in interventions related to mobility and electric vehicles, such as A.15 (101 local government e-vehicles), A.16 (10 fully e-buses + 8 hybrid) and A.24 (Eco-driving patterns to optimize the performance of electric buses). An example of use is shown in Figure 14:

**Smart Sensor for Driving**

```
{
"id": "matchup-mobility-bus-driving:1",
"type": "Vehicle",
"name": "Electric bus 1",
"description": "Electric bus number 1",
"vehicleType": "bus",
"category": ["public, tracked"],
"location": {
  "type": "Point",
  "coordinates": [0.0, 0.0],
  "timestamp": 111111111
}
"previousLocation": {
  "type": "Point",
  "coordinates": [0.0, 0.0],
  "timestamp": 111111111
}
“speed": 90,
```

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```
"heading": 40,
"vehiclePlateIdentifier": "XXXXXX",
"mileageFromOdometer": 123456789,
"serviceProvided": ["urbanTransit"],
"areaServed": "VLC",
"serviceStatus": "onRoute"
}
```

**Figure 14. Smart Sensor for Driving**

**INDICATORS**

Key performance indicators intended to measure the success of an organization or of a particular activity in which it engages.

Key Performance Indicator (KPI) is a type of performance measurement. KPIs evaluate the success of an organization or of a particular activity in which it engages.

This data model defines a type of NGSI entity which captures the value and associated details of a key performance indicator. The data model is flexible enough to accommodate different usage scenarios, such as an entity per KPI calculation or a unique entity per KPI whose value evolves along time.

This model will be used in energy and mobility related actions that obtain any indicator from data. An example of use is shown in Figure 15:

**KPI Data Model**

```
{
  "id": "matchup-kpi-energy-consumption",
  "type": "KeyPerformanceIndicator",
  "name": "Average-Consumption",
  "description": "Average energy consumption in monitored
houses",
  "category": ["quantitative"],
  "organization": {
     "name": "Ayuntamiento de Valencia"
  },
  "kpiValue": 27560,
  "currentStanding": "good",
  "calculationPeriod": {
    "from": "2018-06-01",
    "to":   "2018-06-30",
  },
  "calculationMethod": "automatic",
  "calculationFrequency": "monthly",
  "dateModified": "2018-06-29T15:59:09.224Z",
```

```
  "dateNextCalculation": "2018-07-31",
  "address": {
    "addressLocality": "Valencia",
    "addressCountry": "ESP"
  }
}
```

**Figure 15. Key Performance Indicator example**

**PARKING**

Real time and static parking data (on street and off street) interoperable with the EU standard DATEX II.

These data models are intended to model entities relevant for parking use cases in smart cities scenarios. The main entity types identified are:

- *OffStreetParking*. An offstreet parking site with explicit entries and exits.
- *ParkingAccess*. An access point to an off street parking site.
- *OnStreetParking*. An on street, free entry (but might be metered) parking zone which contains at least one or more adjacent parking spots.
- *ParkingGroup*. A group of parking spots. Granularity level can vary. It can be an storey on a parking garage, an specific area belonging to a big parking lot etc or just a group of spots, differentiated for an specific purpose (usage, restrictions, etc.).
- *ParkingSpot*. An individual, usually monitored, parking spot.

This model will be used in action A.25 (Management of EV parking places). An example of this is shown in Figure 16, which depicts an on-street parking, and in Figure 17, which illustrates a single parking spot.

**On-Street Parking**

```
{
    "id": "matchup-mobility-parking:brujas",
    "type": "OnStreetParking",
    "category": ["blueZone", "shortTerm", "forDisabled"],
    "allowedVehicleType": "car",
    "chargeType": ["temporaryFee"],
    "requiredPermit": ["blueZonePermit", "disabledPermit"],
    "permitActiveHours": {
        "blueZonePermit": "Mo, Tu, We, Th, Fr, Sa 09:00-20:00"
    },
    "maximumAllowedStay": "PT2H",
    "availableSpotNumber": 3,
    "totalSpotNumber": 6,
    "extraSpotNumber": 2,
    "dateModified": "2019-06-02T09:25:55.00Z",
    "location": {
        "type": "Polygon",
        "coordinates": [
```

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```
                [
                    [-3.80356167695194, 43.46296641666926],
                    [-3.803161973253841, 43.46301091092682],
                    [-3.803147082548618, 43.462879859445884],
                    [-3.803536474744068, 43.462838666196674],
                    [-3.80356167695194, 43.46296641666926]
                ]
            ]
        },
    "areaServed": "Zona Centro",
    "refParkingGroup": ["matchup-mobility-parking", "matchup-
mobility-parking-disabled"]
}
```

**Figure 16. On-Street Parking example**

**Parking Spot**

```
{
    "id": "matchup-mobility-parking:brujas:3",
    "type": "ParkingSpot",
    "name": "F-11",
    "location": {
        "type": "Point",
        "coordinates": [-3.80356167695194, 43.46296641666926]
    },
    "status": "free",
    "category": ["onstreet"],
    "refParkingSite": "matchup-mobility-parking:brujas"
}
```

**Figure 17. Parking Spot example**


These data models describe the main entities that are typically involved in waste management scenarios. In fact, these models have been devised to be as generic as possible, thus allowing to deal with different scenarios: municipal waste management with on street/buried containers; industrial waste management using specialized containers; containers used occasionally on street (construction waste containers, etc.); litters placed on street or public places where waste is left by the public. The main entities identified are:

- *WasteContainerIsle* . Isle which holds one or more containers. On a municipal scenario they are delimited on street areas.

- *WasteContainerModel* . It represents a model of waste container, capturing its static properties such as dimensions, materials or features.
- *WasteContainer* . It represents a particular instance of waste container placed at a particular isle or place. All the dynamic properties of a container, for instance, fillingLevel are included by this entity.

Although this FIWARE model is being used in VLCi, it is not planned to be used in this specific project.

**WEATHER**

Weather observed, weather forecasted or warnings about potential extreme weather conditions.

These data models describe entities useful for dealing with weather data. These entities are primarily associated with the vertical segments of the environment and agriculture but is applicable to many different applications. The main entities identified are:

- *WeatherForecast*. It represents a weather forecast for a period of time and a location.
- *WeatherObserved*. It represents a weather observation made over a period of time at a specific location.
- *WeatherAlarm*. It represents a weather alarm intended to raise attention over a forecasted extreme weather condition.

Although this FIWARE model is being used in VLCi, it is not planned to be used in this specific project.

## 5.2 Data model interoperability

NGSI is used to support data exchange and ensure interoperability. NGSI has two interfaces, NGSI-9 (first version) and NGSI-10 (second version), and it provides a series of operations on context information:

- Handle the context information (insert, request, update)

- Subscription/Notification (notifications for subscribers when some context information has changed)

The context information managed by NGSI is based on:

- Entities: They represent real-world objects, such as lampposts, buses, etc.

```
<entity id> <entity_type>
```

- Attributes: They represent the information of real-world objects, such as bus speed.

```
List of <attribute_name, attribute_type, attribute_value>
```

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Both interfaces have a RESTful API via HTTP. This API is used to interact with context. However, depending on the version of NGSI used, interaction is different. Figure 18 describes the interaction using NGSI-9 and Figure 19 depicts the interaction if NGSI-10 is used.

*NGSI-9 API*

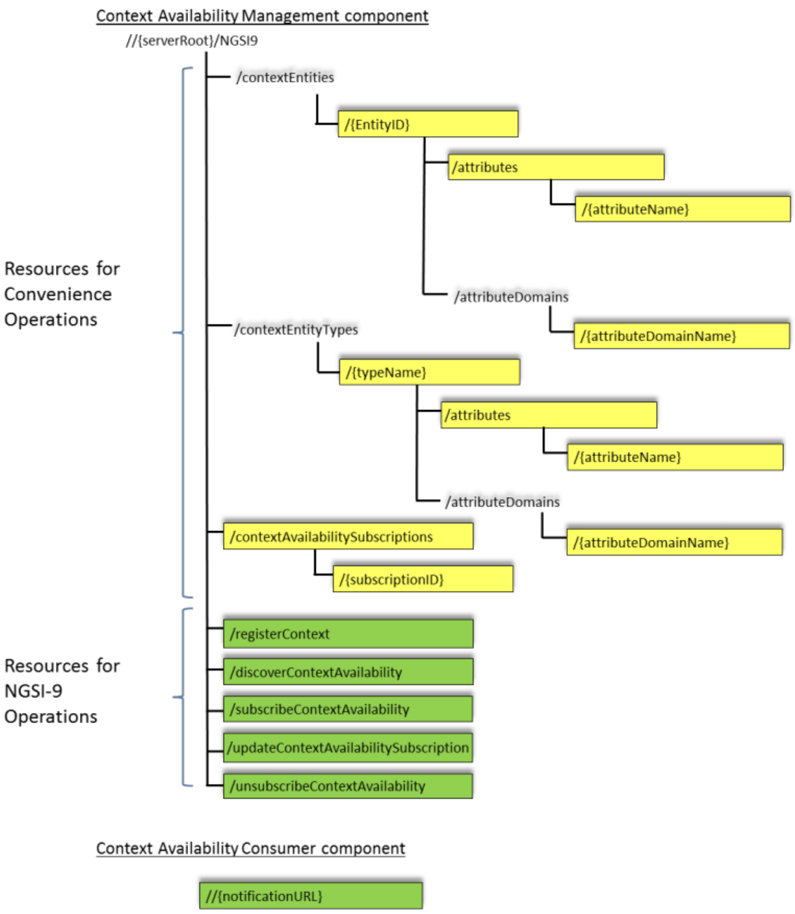


**Figure 18. NGSI-9 API operations**

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*NGSI-10 API*

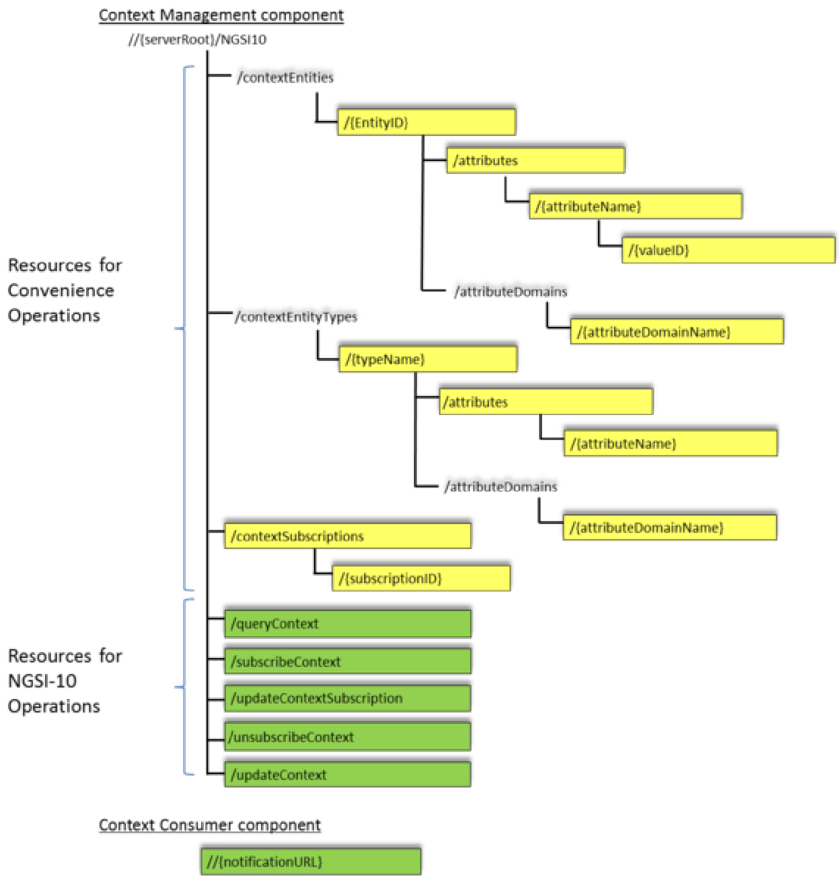


**Figure 19. NGSI-10 API operations**

Finally, some useful operations using the last API version (NGSI-10) are shown below, explaining a use case and describing the request and the response obtained.

### 5.2.1 NGSI-10 Operations

**Entity creation**

When a new entity is created, all the information regarding that entity can be inserted then. NGSI-10 operation: **/updateContext**

*Use case*

Create an entity "House1" with attributes "temperature" (23 degrees) and pressure (720 mmHg)

*Request*

| | |
|---|---|
| Request | http://demo-valencia:1026/v2/entities |
| REST Operation | POST |
| Parameters | - |
| Header | Content-Type: application/json |
| Body | `{ "id": "House1", "pressure": { "metadata": {}, "type": "Integer", "value": 1048 }, "temperature": { "metadata": {}, "type": "Float", "value": 23 }, "type": "House" }` |

**Table 2. NGSI-10 entity creation request**

| | |
|---|---|
| Response Body | - |
| Status | 201 Created |
| Time | 21 ms |

_Response_

**Table 3. NGSI-10 entity creation response**

**Entity request**

Request an entity to obtain all the attributes. NGSI-10 operation: **/contextEntities/EntityId**

_Use case_

Request the value of the attributes of "House1".

_Request_

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| | |
|---|---|
| Request | http://demo-valencia:1026/v2/entities/entityId |
| REST Operation | GET |
| Parameters | entityId = House1 |
| Header | Content-Type: application/json |
| Body | - |

**Table 4. NGSI-10 entity information request**

<table>
<tr><td>Response Body</td><td><pre>{
    "id": "House1",
    "type": "House",
    "pressure": {
        "type": "Integer",
        "value": 720,
        "metadata": {}
    },
    "temperature": {
        "type": "Float",
        "value": 23,
        "metadata": {}
    }
}</pre></td></tr>
<tr><td>Status</td><td>200 OK</td></tr>
<tr><td>Time</td><td>24 ms</td></tr>
</table>

*Response*

**Table 5. NGSI-10 entity information response**

For more information on NSGI-10, [7] can be examined.

## 5.3 Open data catalogues

The city of Valencia already has a catalogue of open data, available on the *Portal de Transparencia y Datos Abiertos* (Transparency and Open Data Website) of the City Council of Valencia [8]. This portal is based on CKAN (Comprehensive Knowledge Archive Network) and it acts as a tool for open data portals, facilitating the management and publication of data collections.

Also, DCAT-AP (DCAT Application profile) is a specification based on Data Catalogue vocabulary (DCAT), designed to standardize the descriptions of the datasets published in the different open data portals in Europe [9].

In this context, it is worth highlighting that this portal can be accessed by any citizen. In addition, most of the data and information generated by the implementation of the project actions will be published as public data in this catalogue. A specific section of

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open data catalogue will be created with the new datasets generated in this project, obtained from the data collection systems used.

We still need to specify what information will be published in the open data portal, but we can give some examples of actions that are expected to publish open information, which are the following:

### 5.3.1 Energy scope

1) Smart lighting (lamppost):

- A.27. Smart lighting + 4000 street lamps

A network of sensors and actuators will be provided, which will collect data on energy consumption and other variables. Before publishing data, a work of filtering which information is relevant for citizens and which one should be kept private, should be done. The control and diagnosis of the smart lighting is a task that the operators have to do and it cannot be openly accessible. However, information regarding energy consumption and working hours of streetlights is information that improves transparency and may awaken interest among citizens committed to the environment.

2) Smart controllers for buildings and houses:

- A.5. Next generation of smart controls

- A.4. Smart meters for buildings

Public and private buildings and houses participating in this project will be provided with sensors to collect data of comfort parameters, power consumption, energy generation, and energy storage. Public buildings may share these measurements as public data together with information about the building characteristics and location. Private buildings and dwellings will not openly share sensitive information. Instead, anonymized information is published, filtered and aggregated following certain guidelines.

### 5.3.2 Mobility scope

1) Vehicle charging:

- A.20. Management of charging system and Management of EV parking places

An intelligent and comprehensive electric vehicle charging management system will be developed and implemented in the city of Valencia. This action includes the supply and deployment of charging posts, as well as the software necessary for their management. Data about vehicle charging process will be collected. Whereas billing and other sensitive information will be kept private, the usage status and statistics may be published in the open data portal.

2) Buses

- A.16. 10 fully eBuses + 8 hybrid

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The performance of these vehicles will be monitored during the life of the project and the information will be provided into VLCi platform for data statistics and data mining studies to evaluate the performance of the service. Public data within this information will be selected and published to provide open insights for citizens.

- A.24. Eco-driving patterns to optimize the performance of electric buses

A conduction monitoring system will be implemented with sensors installed in several buses of the Municipal Transport Company (EMT), in order to monitor driving performance. Comfort and people, consumption and driving data will be collected. Information about driving patterns is collected and driving alerts and recommendations are generated. Due to privacy policies, not all this information can be published as open data but interesting indicators can be distributed, such as power consumption reduction due to the driving recommendations.

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# 6 Interoperability tests for interventions

The interoperability tests will allow to validate the process or flow that information follows in relation to the Urban Platform in each of the project actions or interventions. These tests have been shaped in different use cases, depending on the treatment carried out on the information. Therefore, the considered use cases are the following:

*1. Use cases for inserting data into the platform*

They should take into account the acquisition of data from sensors and external systems to be stored in the platform.

*2. Use cases for transforming data in the platform*

They include the operations carried out in the platform using the data available to generate aggregations of data or inferred data.

*3. Use cases for requesting platform data*

They involve the visualization and extraction of data stored on the platform, either by final users or other modes that use this information for their calculations.

*4. Use cases for sending data from the platform*

In case there exists any device that acts as an actuator, these use cases include sending notifications or orders as a result of the entry of data into the platform or of administrative tasks.

*5. Use cases for supply*

They are related to provisioning operations and are provided by any of the devices available on the platform. The provisioning use cases do not represent an integration in themselves, but rather a precondition for the different integrations described above.

This is the main classification of use cases. At this stage of the project, the first kind of use cases has been designed and it is described below. The rest of use cases will be defined in the following months and reported in the next version of this deliverable.

## 6.1 Use cases for inserting data into the platform

The use cases that are related to the data-loading interfaces available on the platform are shown below. These cases can be classified according to the origin of the data:

*1.1 Insertion of data from sensors*

Data from sensors or devices that enter the system through IoT Agents.

*1.2 Insertion of data from ETL processes*

Data from extraction, transformation and loading processes, that can access different platform repositories either directly or through the Context Broker. The usage of the Context Broker is recommended, as it allows the data inserted globally into the platform to be standardized, while also facilitating the insertion of future repositories without need for additional development. These integrations are especially appropriate in integrations that are not in real time (non-RT).

*1.3 Insertion of data from ESB applications*

Data from applications connected through a service bus that encapsulates the data insertion interface through a Context Broker. These integrations are especially appropriate for processes in real time (RT).

*1.4 Insertion of data from NGSI applications*

Data from applications developed to interact directly with the NGSI interface presented by the Context Broker.

The nature of the information to be inserted with each of the interfaces is not a relevant question from the point of view of the platform, as each of the prepared channels can be used to integrate data generated by or coming from sources external to the platform, used to calculate indicators related to the parameters for the city or services.

In VLCi platform, there are four different storage points. Although they have commonalities, the flow of information in each one is also different. The storage points, also called sinks, are the following:

*Short-Term Historic (STH)*

The STH is in charge of managing (storing and retrieving) historical raw and aggregated time series information about the evolution in time of context data (i.e., entity attribute values) registered in an Orion Context Broker instance.

*Analytical Database (ADB)*

The ADB makes the information stored internally in the platform available to the presentation layer. This way, the analytical database ensures that the waiting time for users who want to view data in the presentation layer is minimal.

*Open Data Portal (CKAN)*

CKAN is a tool for open data web portals. It facilitates the management and publication of collections of data. It is widely used by national, regional and local governments, research centres and other types of organizations that accumulate large quantities of information.

Once the data is published, users can use specific searches, both on the level of the portal and through API access, to navigate and find the data they need. They can also preview them using maps, graphs and tables. The audience this data is aimed at includes profiles as diverse as developers, journalists, researchers, members of NGOs, citizens and even internal staff from the organization.

*Big Data (HADOOP)*

The Big Data solution for IoT is based on Apache Hadoop, which is a free code framework for the storage and large-scale processing of data in clusters of consumer-level hardware.

The framework for Apache Hadoop is made up of the following modules:

- Hadoop Common – contains libraries and utilities needed for other Hadoop modules.

- Hadoop Distributed File System (HDFS) – a distributed file system that stores data in consumer equipment, providing a very high bandwidth on a cluster level.

- Hadoop YARN – a responsible resource management platform for managing computing resources available in clusters and their use for scheduling user applications.

- Hadoop MapReduce – a programming model for processing data on a large scale.

### 6.1.1 Insertion of data from sensors

In this use case, the insertion from external devices is considered. Also, in these set of intervention tests the entry point is any of the different IoT Agents available in the platform. The communication protocols currently supported by the platform for the reception of measures by the IoT Agents are UL2.0 and JSON, allowing either HTTP or MQTT to be used as higher-level protocols. In case any other protocol was needed, the corresponding IoT Agent could be developed.

As a general rule, the use of IoT Agents does not require to know in advance the device that is sending measurements. However, there are scenarios that require the devices to be provided in order to obtain the expected results. That is, when the device sends parameter X through protocol P and it has to be published as attribute A, this rule needs to be established for configuring the device in the IoT Agent so that the behaviour is as expected.

Therefore, a device will need to provision itself in the IoT Agent when a specific transformation of the information sent by the device is needed, which will determine how this information is published in the Context Broker. Not only is it possible to decide how information sent by a device will be published, but also we can even establish additional static data that will also be published, e.g. the colour of the device or the location of a static device or the name of the entity that all the information on the device in the Context Broker will be associated with. Hence, provisioning the devices in the platform beforehand will provide greater control over them.

**Insertion of data from sensors towards Short-Term Historic**

Figure 20 depicts the flow of data sent from sensors and inserted into the STH:

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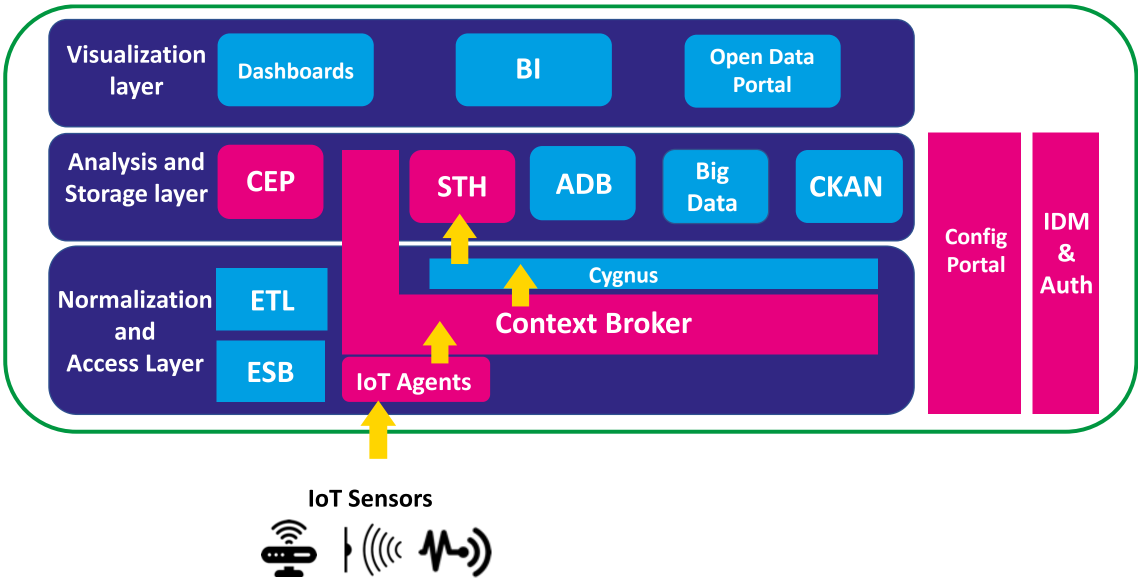


**Figure 20. Flow of insertion of data from sensors towards STH**

In order to be able to insert data from sensors into the short-term historic, the following steps are necessary:

1. Check that there is a platform subservice associated and there is a subservice user with admin privileges, or create them otherwise.

2. Provision the communication protocol that the sensor uses in the IoT Agent. This can be done either through the administration portal or through the API. Note that in both cases the subservice admin user must be used, either entering credentials or using a token. Once provisioned, a necessary *apikey* will be obtained to send measurements.

3. Provision the devices to be used in the IoT Agent. This can be done either through the administration portal or through the API. The *device_id* needed for sending measurements will be obtained.

4. Provision the subscription to the short-term historic in the Context Broker. This can be done either through the administration portal or through the API.

Once the *apikey* and the *device_id* have been obtained, data from the sensors could be sent to the platform. Figure 21 shows the diagram of insertion sequence of data, the protocol requests and responses.

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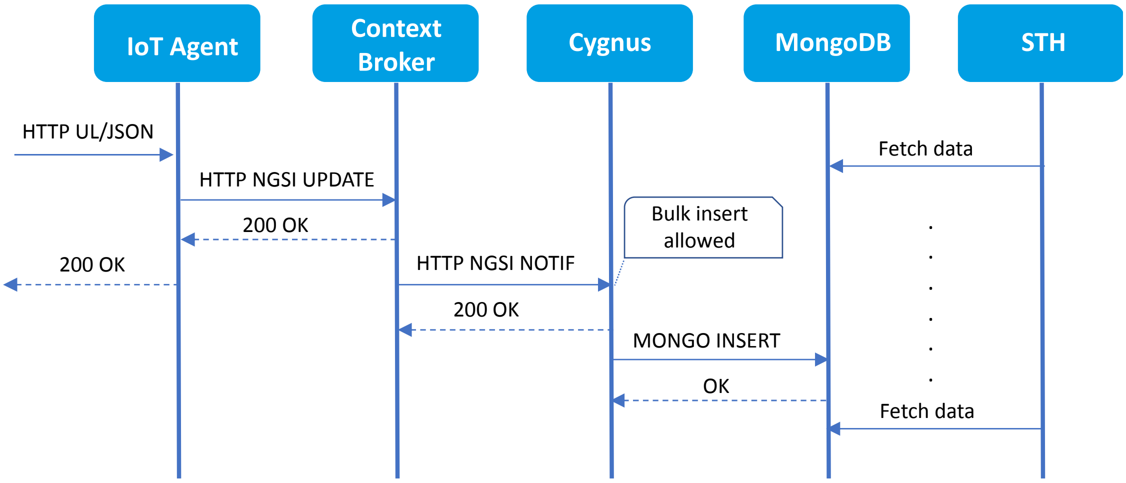


**Figure 21. Diagram of insertion sequence of data from sensors towards STH**

### Insertion of data from sensors towards Big Data

Figure 22 depicts the flow of data sent from sensors to be inserted into Big Data storage:

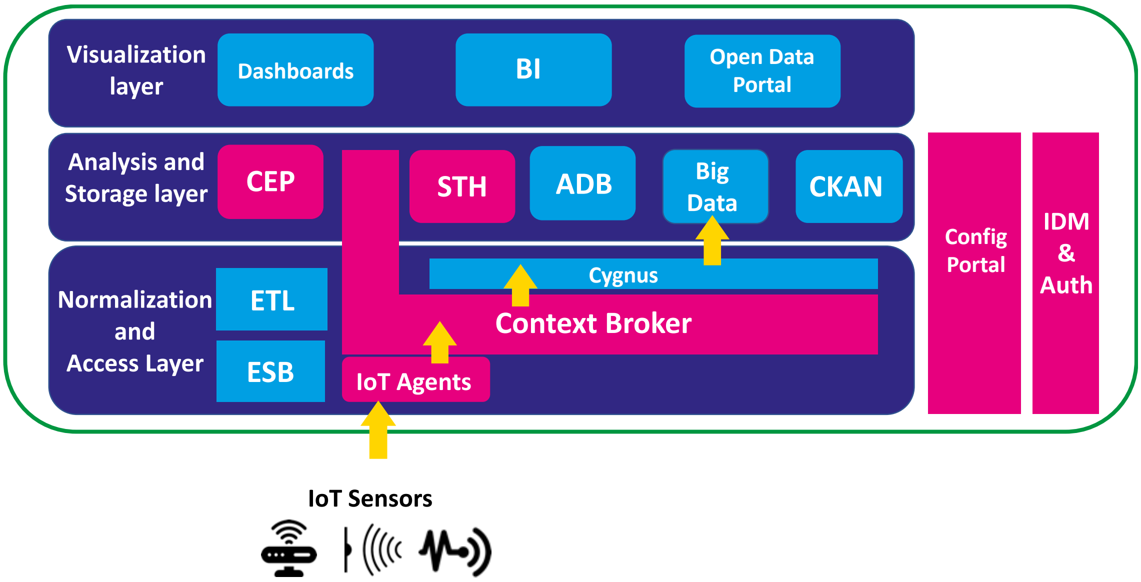


**Figure 22. Flow of insertion of data from sensors towards Big Data**

In order to be able to insert data from the sensors in Big Data, similar steps to STH insertion must be followed, but the subscription has to be done to a different sink. The steps are as follows:

1. Check that there is a platform subservice associated and there is a subservice user with admin privileges, or create them otherwise.

2. Provision the communication protocol that the sensor uses in the IoT Agent. This can be done either through the administration portal or through the API. Note that in both cases the subservice admin user must be used, either entering credentials or using a token. Once provisioned, a necessary *apikey* will be obtained to send measurements.

3. Provision the devices to be used in the IoT Agent. This can be done either through the administration portal or through the API. The *device_id* needed for sending measurements will be obtained.

4. Provision the subscription to Big Data in the Context Broker. This can be done either through the administration portal or through the API.

Once the *apikey* and the *device_id* have been obtained, data from the sensors could be sent to the platform. Figure 23 illustrates the diagram of insertion sequence of data, the protocol requests and responses.

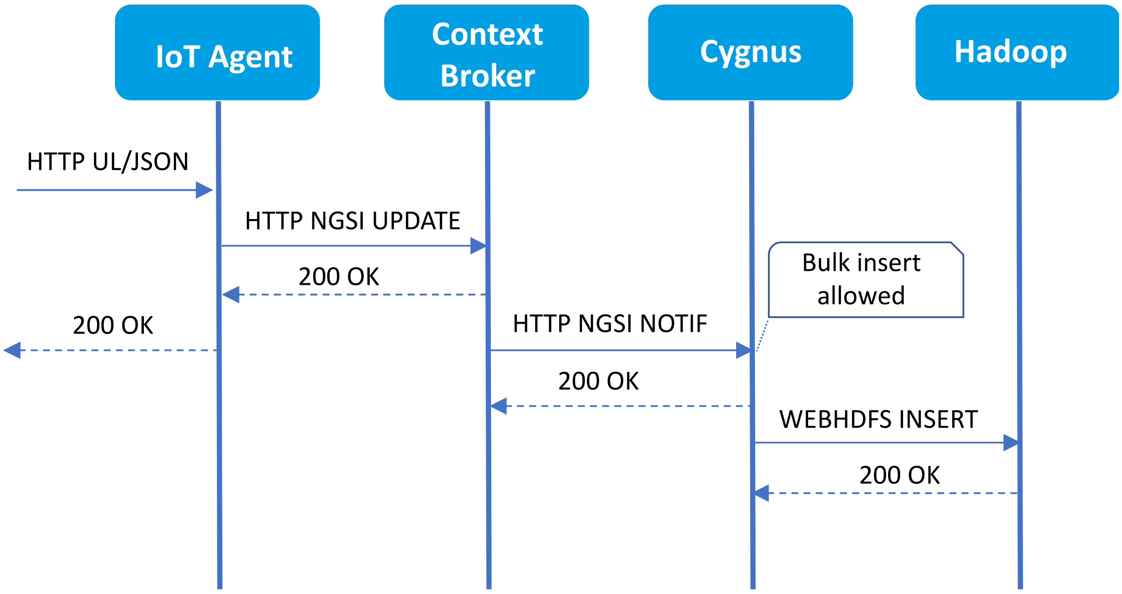


**Figure 23. Diagram of insertion sequence of data from sensors towards Big Data**

### Insertion of data from sensors towards the Analytical Database

Figure 24 illustrates the flow of data sent from sensors to be inserted into the Analytical Database:

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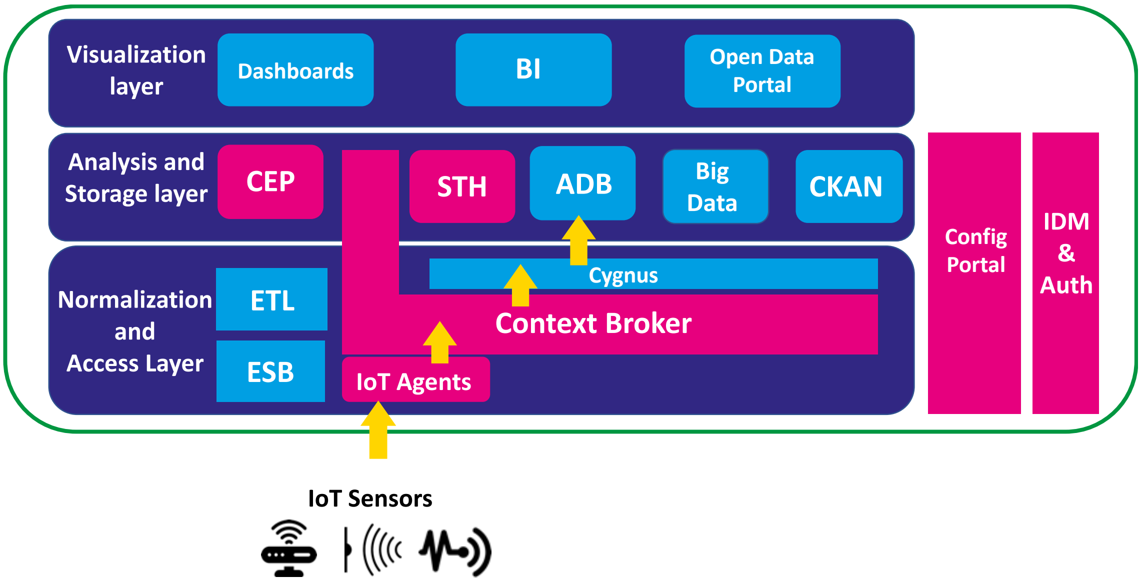


**Figure 24. Flow of insertion of data from sensors towards the Analytical Database**

In order to be able to insert data from the sensors into the Analytical Database, the following steps are necessary:

1. Check that there is a platform subservice associated and there is a subservice user with admin privileges, or create them otherwise.

2. Provision the communication protocol that the sensor uses in the IoT Agent. This can be done either through the administration portal or through the API. Note that in both cases the subservice admin user must be used, either entering credentials or using a token. Once provisioned, a necessary *apikey* will be obtained to send measurements.

3. Provision the devices to be used in the IoT Agent. This can be done either through the administration portal or through the API. The *device_id* needed for sending measurements will be obtained.

4. A database must be created in the ADB. Some requirements must be fulfilled. The name of the database must be the same as the name of the service, and the name of the tables must be in the form <subservice>_<entity_id>_<entity_type>. The columns of the table will be the names of the attributes. In addition, the following columns must be provisioned: recvTime, fiwareservicepath, entityId, entityType, and the corresponding columns of metadata for the attributes, which will be named in the form <attribute>_md. The types of the columns must be VARCHAR (250) except for the recvTime column, which will be type TIMESTAMP.

5. Provision the subscription to the Analytical Database in the Context Broker. This can be done either through the administration portal or through the API.

Once the *apikey* and the *device_id* have been obtained, data from the sensors could be sent to the platform. Figure 25 depicts the diagram of insertion sequence of data, the protocol requests and responses.

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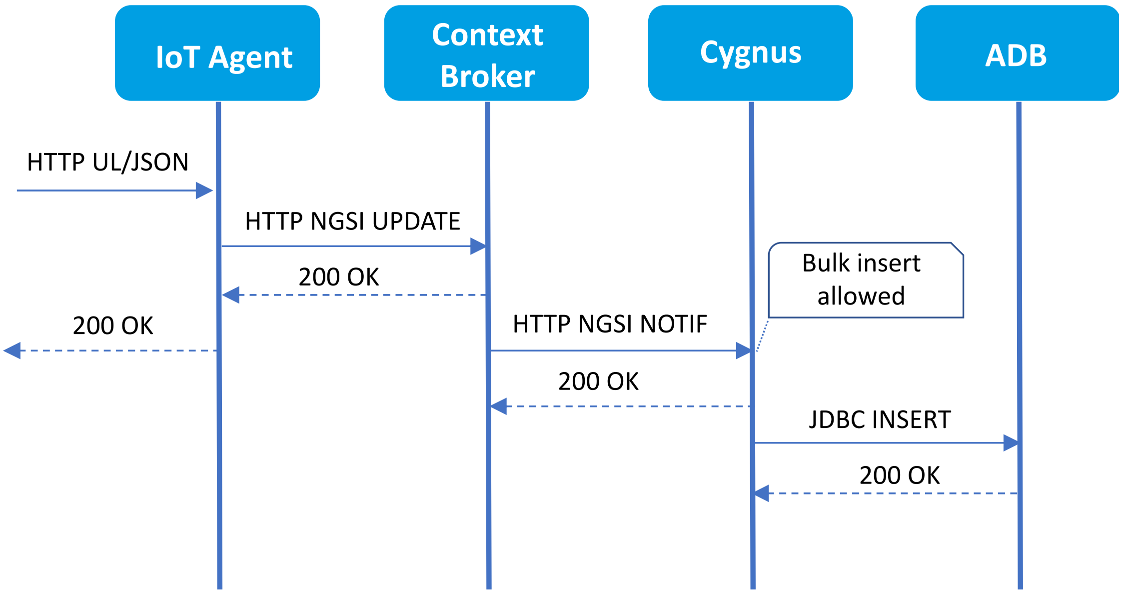


**Figure 25. Diagram of insertion sequence of data from sensors to the Analytical Database**

### Insertion of data from sensors towards the Open Data Portal

Figure 26 shows the flow of data sent from sensors to be inserted into the Open Data Portal:

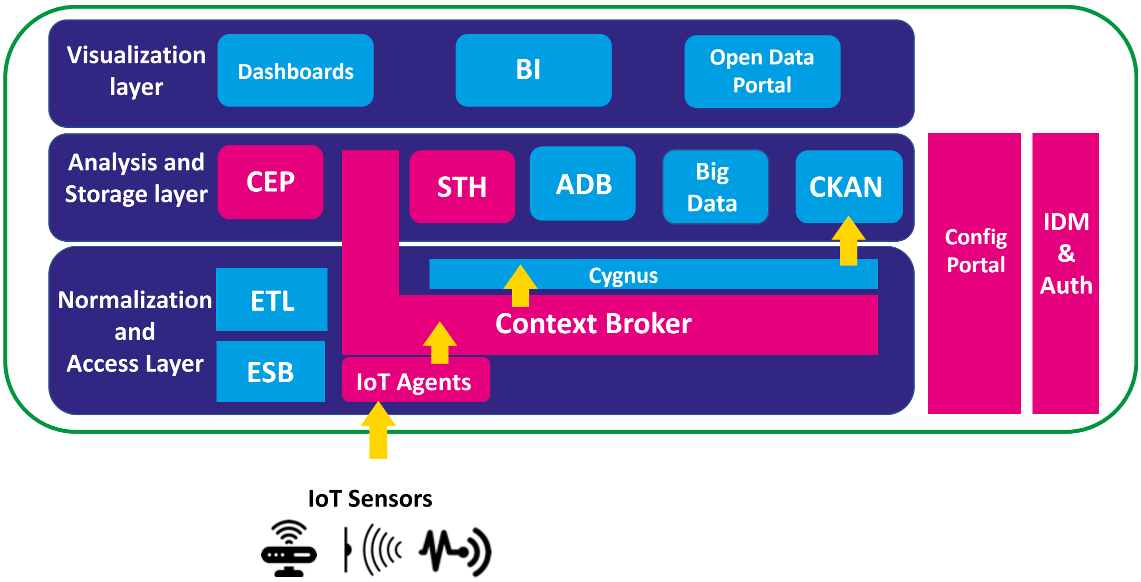


**Figure 26. Flow of insertion of data from sensors towards the Open Data Portal**

In order to be able to insert data from the sensors into the Open Data portal, the following steps are necessary:

1. Check that there is a platform subservice associated and there is a subservice user with admin privileges, or create them otherwise.

2. Provision the communication protocol that the sensor uses in the IoT Agent. This can be done either through the administration portal or through the API. Note that in both cases the subservice admin user must be used, either entering credentials or

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using a token. Once provisioned, a necessary *apikey* will be obtained to send measurements.

3. Provision the devices to be used in the IoT Agent. This can be done either through the administration portal or through the API. The *device_id* needed for sending measurements will be obtained.

4. Provision the subscription to the Open Data Portal in the Context Broker. This can be done either through the administration portal or through the API.

Once the *apikey* and the *device_id* have been obtained, data from the sensors could be sent to the platform. Figure 27 illustrates the diagram of insertion sequence of data, the protocol requests and responses.

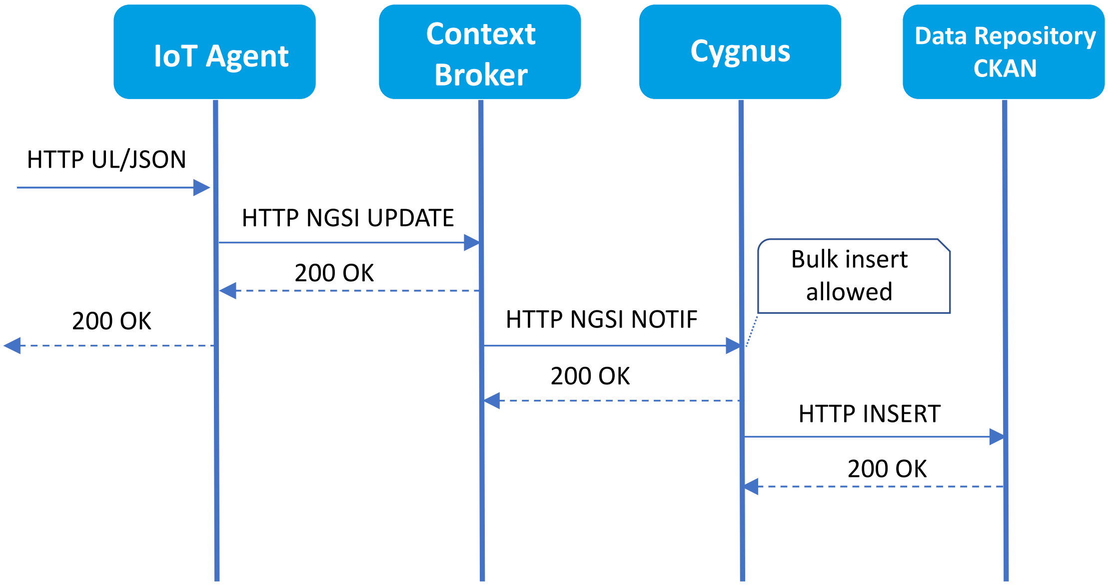


**Figure 27. Diagram of insertion sequence of data from sensors to the Open Data Portal**

## 6.2 Use cases for transforming data within the platform

The use cases for transforming data within the platform are those in which data stored in the platform are taken and aggregated or processed in a way that new data relevant to the city is generated. As a result, these use cases cannot be entirely defined beforehand, since they will depend on the nature of the processing we wish to apply to the data in question. For example, the construction of complex rules or the inference of certain interrelations using a Big Data analysis. These cases will then be classified according to the component carrying out the transformation.

### 6.2.1 Performing Big Data analysis operations

In those cases when data is saved in the Big Data storage (based on HDFS) to accommodate a big amount of information, the analysis operations can be done directly in the Big Data module. This is done using MapReduce processes and the transformation outcomes could be stored also in this module or sent back to entities in other sink of the platform. Figure 28 illustrates the flow of data for Big Data transformations.

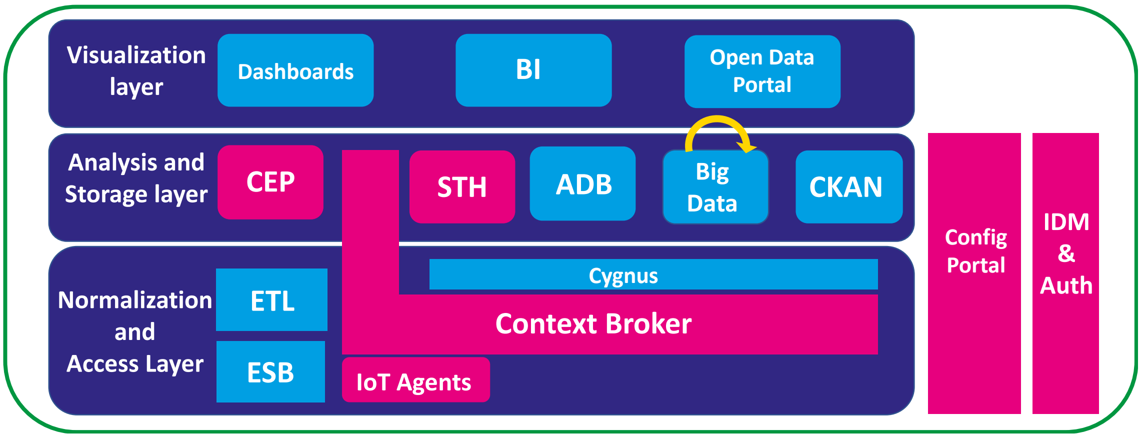


**Figure 28. Flow of transformation of data from Big Data**

In MAtchUP, intervention A.24 about driving patterns in electrical buses is using a MapReduce function in order to find inefficient driving patterns and alert drivers and send efficient driving recommendations afterwards in order to improve battery life and usage.

# 7 Security aspects

Actually, management of data is one of the challenges presented by this project, since when collecting data from the city, personal or private data of citizens can be compromised, such as their home location. Through their home location and other information, citizens could be identified. Therefore, security aspects and regulations must be considered to prevent third parties from accessing the aforementioned data and to be able to identify citizens.

## 7.1 Regulations of Security

### 7.1.1 EU General Data Protection Regulation (GDPR)

The regulation 2016/679 of the European Union [10] published on April 27, 2016 and of application on the 25th of May 2018 (two years for organizations to adapt to the regulation), called GDPR, establishes the rules regarding the protection of natural persons with regard to the processing of personal data and the rules relating to the free movement of these data.

Some relevant considerations of the regulation are presented below:

*- "1. The protection of natural persons in relation to the processing of personal data is a fundamental right.(...)",*

*- "7. (…) Natural persons should have control of their own personal data. (...)",*

Personal data is any information about an identified or identifiable natural person, i.e. whose identity can be determined, directly or indirectly, by means of a name, personal identification number, location data, etc.

*- "26. The principles of data protection should apply to any information concerning an identified or identifiable natural person. Personal data which have undergone pseudonymisation, which could be attributed to a natural person by the use of additional information should be considered to be information on an identifiable natural person. To determine whether a natural person is identifiable, account should be taken of all the means reasonably likely to be used, such as singling out, either by the controller or by another person to identify the natural person directly or indirectly. To ascertain whether means are reasonably likely to be used to identify the natural person, account should be taken of all objective factors, such as the costs of and the amount of time required for identification, taking into consideration the available technology at the time of the processing and technological developments. The principles of data protection should therefore not apply to anonymous information, namely information which does not relate to an identified or identifiable natural person or to personal data rendered anonymous in such a manner that the data subject is not or no longer identifiable. This Regulation does not therefore concern the processing of such anonymous information, including for statistical or research purposes.".*

Pseudonymization consists of replacing some personal data with pseudonyms to make private data less identifiable, i.e. transform personal data with the help of, for example, an encryption key so that the resulting data are unintelligible and cannot identify a person without the use of that additional information (encryption key). In addition, the encryption key and the encrypted data must be stored in different locations to reduce

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risk. Nevertheless, it is worth mentioning that the pseudonymized data is still considered personal data.

Another option could be the use of the anonymization of data, which eliminates the possibility of correlating personal identifiers with other data, at the expense of being less flexible than pseudonymization.

*- “32. Consent should be given by a clear affirmative act establishing a freely given, specific, informed and unambiguous indication of the data subject's agreement to the processing of personal data relating to him or her, such as by a written statement, including by electronic means, or an oral statement. (...)”*

In light of this, citizens who participate in some project activities will be asked for express consent if their personal data were collected.

*- “39. Any processing of personal data should be lawful and fair. It should be transparent to natural persons that personal data concerning them are collected, used, consulted or otherwise processed and to what extent the personal data are or will be processed. (...)”*

In consequence, citizens participating in certain project actions will be asked for the express consent of their personal data and how it will be used.

*- “42. Where processing is based on the data subject's consent, the controller should be able to demonstrate that the data subject has given consent to the processing operation. In particular in the context of a written declaration on another matter, safeguards should ensure that the data subject is aware of the fact that and the extent to which consent is given. (...) a declaration of consent preformulated by the controller should be provided in an intelligible and easily accessible form, using clear and plain language and it should not contain unfair terms. (...) For consent to be informed, the data subject should be aware at least of the identity of the controller and the purposes of the processing for which the personal data are intended (...)”*

Express consent will be reflected in a document of written consent, with an appropriate and easy-to-understand language for any citizen (in Spanish and Valencian) with the identity of the person responsible for processing the data, clearly indicating what data is wanted for (the purpose).

*- “51. Personal data which are, by their nature, particularly sensitive in relation to fundamental rights and freedoms merit specific protection as the context of their processing could create significant risks to the fundamental rights and freedoms. Those personal data should include personal data revealing racial or ethnic origin, whereby the use of the term ‘racial origin’ (...)”*

The project will not deal with special or sensitive data of citizens (political opinions, religious convictions, philosophical convictions, racial or ethnic origin, data related to health, for example).

### 7.1.2 Personally Identifiable Information (PII)

Personally Identifiable Information (PII) is any data that could potentially be used to identify a particular person. For instance, this information could contain name and surname, house address, email address, birthday, phone number and geographic information. This is the type of information that must be taken into account to decide if the GDPR should be applied. Figure 29 depicts an example of PII.

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**Figure 29. Personally Identifiable Information**

### 7.1.3 EU Members Adaptation of GDPR

There are countries with their own regulations already adapted to the GDPR, such as Sweden, UK, Holland or Germany. However, other countries are still in process of updating the national standard. The GDPR intends to improve transparency and aspires to create harmonization of differing national data protection schemes as well as digital confidence among consumers. Spain has just taken actions to adapt regulation to this new paradigm.

**Spain Adaptation of GDPR**

In Spain, there was the Organic Law on the Protection of Personal Data (LOPD) 15/1999 but the new regulation approved on December 5th left obsolete that law. The new regulation is the Organic Law 3/2018 on the Protection of Personal Data and the Guarantee of Digital Rights [11], which describes five key issues: The object of the law, the data protection officer figure, data subject rights, the processing of personal data by political parties, and digital rights.

This law adapts the Spanish legal system to the General Data Protection Regulation and additionally provides specifications or restrictions of some of the rules explained in the GDPR and includes some specifications with regard to data subjects' rights, additional DPO functions, among others.

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# 8 Action plan

All the actions from Valencia Demo site are reflected in deliverable D2.14. Among them, the specific actions that have a technological component must be studied within the ICT framework. In this context, these actions are based on the use of sensors to obtain measurements and send them to the urban platform. During the first year, the sensors that will be used in the project to monitor houses, buildings, buses, and other components have been design and developed, and during this second year, the development has been mostly finished and tests have been performed in real environments.

Once the sensors have been developed, data models have been defined in order to enable the exchange of information from the sensors and the urban platform. The urban platform of Valencia is based on FIWARE and, therefore, complies with European standards. This facilitates communication between the elements of the Smart City architecture, guaranteeing the vertical interoperability and favouring the horizontal interoperability among cities.

Additionally, the integration of the services created for the different verticals of the platform (mobility, energy, ICT) have started. To do this, new services have been created on the VLCi platform, and new endpoints have been made available for each of the subservices. First integration tests have been carried out satisfactorily, integrating energy consumption sensors. The estimated timeline for the next interoperability tests is shown in Figure 30.

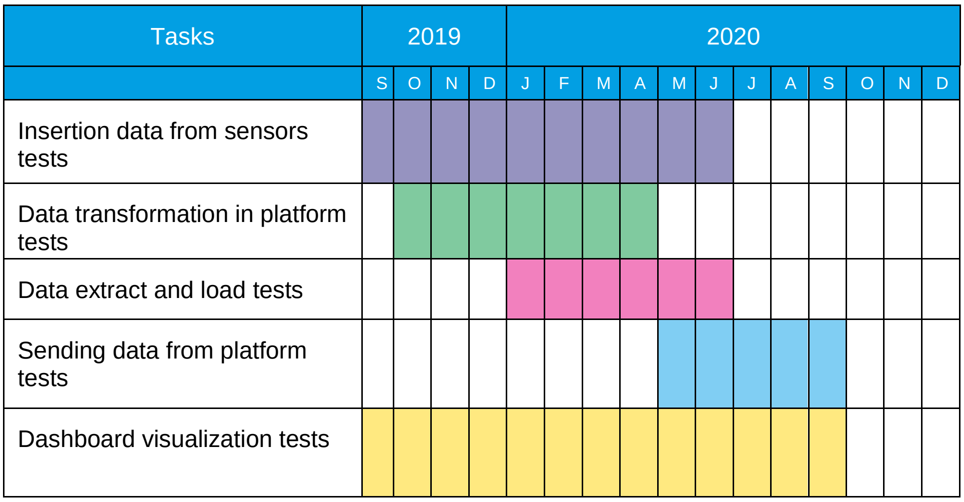


**Figure 30. Estimated timeline diagram for interoperability tests**

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# 9 Conclusions

This deliverable has shown the current state of concept and development of the urban platform integration tests and interoperability in Valencia demo site.

When designing, implementing and deploying a Smart City system, there are several barriers that should be taken into account. One of the most important barrier to overcome is interoperability issues and dealing with hermetic implementations. Cities often tackle challenges in a phased approach, due to annual budgeting and as well as legacy issues that separate city functions into separate, proprietary solutions with little or no interaction. As a result, many projects are built to solve a single problem in a single department, creating isolated modules that duplicate expenses while making it difficult to share systems or data.

In this sense, interoperability ensures that products and services from disparate providers can exchange information and work together seamlessly. Interoperability has many benefits, such as facilitating transparency or allowing city management to choose between many suppliers, minimizing acquisition costs and be bound by agreements. Also, one of the main advantages of providing interoperability is the fact that it allows future services and solutions to be built without concern about whether newly added modules will operate seamlessly with those deployed earlier.

Following this insight, in this deliverable, the concept of interoperability has been defined and presented as an essential factor that facilitates communication among the modules in an urban platform, enumerating the main standards that deal with interoperability and format issues. Additionally, the adaptations and extensions to the existing VLCi urban platform have been studied in order to understand and design the integration of the new services proposed in this project. In this sense, new data models are defined for these new services. These data models are based on FIWARE data models, since VLCi is an implementation of the FIWARE architecture. This design will help achieve vertical interoperability between components. The catalog of datasets is still under development and will be finished in the final version of this deliverable. Furthermore, first interoperability tests have been defined in order to check the integration of the new services with the VLCi platform. Interoperability tests for remaining modules are also planned, and they will be included in future versions of this deliverable.

Moreover, since private data could be stored and processed in the urban platform, the new European General Data Protection Regulation (GDPR) must be taken into account. A detailed revision of this law has been carried out in order to assess how it can affect developments and integration in this project. Also, the action plan is presented, with information about next steps and developments that will be carried out in order to implement the remaining interoperability and integration tests.

In summary, interoperability allows smart cities to operate seamlessly and reduce undesired cost overruns. By defining common data formats and protocols, the urban platform is able to deploy new frictionless services. These are some of the main reasons why interoperability has become so relevant in urban platform developments.

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# 10 References

[1] INTER-IoT Eurpoean Project and project datasheet. http://www.inter-iot-project.eu/, https://cordis.europa.eu/project/rcn/199587_en.html

[2] i-SCOPE European Project datasheet https://cordis.europa.eu/project/rcn/191922_en.html

[3] IDABC programme. http://ec.europa.eu/idabc/en/chapter/3.html

[4] Schema.org community. https://schema.org/

[5] FIWARE Data Models: https://www.fiware.org/developers/data-models/

[6] Open311 Open Standard. http://www.open311.org/

[7] FIWARE-NGSI v2 Specification. https://orioncontextbroker.docs.apiary.io/#]

[8] Transparency and Open Data Website of Valencia. http://gobiernoabierto.valencia.es/en

[9] DCAT application profile for data portals in Europe. https://joinup.ec.europa.eu/solution/dcat-application-profile-data-portals-europe

[10] General Data Protection Regulation. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2016:119:TOC

[11] Protection of Personal Data and the Guarantee of Digital Rights, Organic Law 3/2018. https://www.boe.es/eli/es/lo/2018/12/05/3

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