



Innovation Action
H2020-LC-SC3-SCC-1-2018

D5.9 - ICT-City Platforms: common open specifications

WP5; Task 5.5

November 2019 [M12]

Author(s): Gerard van de Kamp (CGI), Peter Hut (CGI), Sophie Dourlens-Quaranta (R2M), Klaus Käsälä (VTT)



www.makingcity.eu



[@MakingCity_EU](https://twitter.com/MakingCity_EU)



This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement n°824418.

Disclaimer

The content of this deliverable reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.

Copyright notice

©2019 MAKING-CITY Consortium Partners. All rights reserved. MAKING-CITY is a HORIZON2020 Project supported by the European Commission under contract No. 824418. For more information on the project, its partners and contributors, please see the MAKING-CITY website (www.makingcity.eu/). You are permitted to copy and distribute verbatim copies of this document, containing this copyright notice, but modifying this document is not allowed. All contents are reserved by default and may not be disclosed to third parties without the written consent of the MAKING-CITY partners, except as mandated by the European Commission contract, for reviewing and dissemination purposes. All trademarks and other rights on third party products mentioned in this document are acknowledged and owned by the respective holders. The information contained in this document represents the views of MAKING-CITY members as of the date they are published. The MAKING-CITY consortium does not guarantee that any information contained herein is e-free, or up-to-date, nor makes warranties, express, implied, or statutory, by publishing this document.

Document Information

Grant agreement	824418
Project title	Energy efficient pathway for the city transformation: enabling a positive future
Project acronym	MAKING-CITY
Project coordinator	Cecilia Sanz-Montalvillo (cecsan@cartif.es)- Fundación CARTIF
Project duration	1 st December 2018 – 30 th November 2023 (60 Months)
Related work package	WP 5 – Evaluation framework and social innovation
Related task(s)	Task 5.5 – ICT Urban Platform
Lead organisation	09-CGI & 20-VTT
Contributing partners	03-GRO, 09-CGI, 10-SB, 13-OUK, 20-VTT
Due date of deliverable	30 th November 2019
Actual submission date	30 th November 2019, 31 st May 2020
Dissemination level	Public

Date	Version	Submitted by	Reviewed by	Comments
16/04/2019	0.1.0	CGI	Gerard van de Kamp	Outline
07/08/2019	0.1.1	CGI	Peter Hut	Added draft contents
09/08/2019	0.2.0	CGI	Gerard van de Kamp	Reviewed
08/10/2019	0.2.1	CGI	Peter Hut	Updated with comments from Cartif
10/10/2019	0.3.0	CGI	Jonathan Hobelman	Reviewed
21/11/2019	0.3.1	R2M	Sophie Dourlens-Quaranta	Reviewed
22/11/2019	0.3.2	CGI	Peter Hut	Updated CIP diagram
29/11/2019	0.4.0	CGI	Peter Hut	Updated based on review comments.

01/12/2019	1.0.0	CAR	Cecilia Sanz-Montalvillo	Finalized
06/05/2020	1.0.1	CGI	Peter Hut / Ynze Zijlstra	Updated based on PO comments
26/05/2020	1.0.2	VTT	Klaus Käsälä	Updated BIM section and added Oulu specific information
29/05/2020	1.1.0	CGI	Ynze Zijlstra	Reviewed
29/05/2020	2.0.0	CAR	Cecilia Sanz-Montalvillo	Finalized

Table of content

Executive Summary.....	8
1 Introduction.....	9
1.1 Purpose and target group.....	9
1.2 Contribution partners.....	9
1.3 Relation to other activities in the project.....	9
2 Existing open specification frameworks.....	12
2.1 Urban Platform References	12
2.1.1 EIP-SCC Urban Reference Architecture and ESPRESSO.....	12
2.1.2 Urban Platforms in Lighthouse Projects.....	13
2.2 MAKING-CITY Urban Data Platform reference architecture	15
2.2.1 Data management framework.....	15
2.2.2 Data Market.....	16
2.2.3 Security and privacy.....	16
2.2.4 Platform Management.....	16
2.3 Reusable components	16
2.3.1 FIWARE	16
2.3.2 CKAN	16
2.4 MAKING-CITY requirements & stakeholders.....	17
2.5 KPI standardization	18
2.5.1 SCIS	18
2.5.2 CITYkeys.....	19
3 Interoperability standards	20
3.1 Data Market.....	20
3.1.1 Register.....	20
3.1.2 API Management	21
3.2 Data Management Framework.....	22
3.2.1 Building	22
3.2.2 City.....	22
3.2.3 Measurements / History	23
3.3 Security and Privacy.....	24
3.4 Platform management.....	25
3.5 Connectivity.....	25
3.5.1 Buildings.....	25
3.5.2 Charge points.....	25
4 Open specification of the MAKING-CITY Urban Data Platform	26
4.1 Lighthouse cities	26
4.1.1 Oulu	26
4.1.2 Groningen	27
4.2 Follower Cities	27
5 Conclusions.....	28
Bibliography.....	29

List of figures

Figure 1: ESPRESSO reference architecture (ESPRESSO, 2017)	13
Figure 2: IRIS City Innovation Platform (IRIS, 2018a)	14
Figure 3: MAKING-CITY Urban Data Platform reference architecture	15
Figure 4: Stakeholders in City Innovation Platform ecosystem (IRIS, 2018b).....	17
Figure 5: SensorThings API entities (OGC, 2019)	24

List of tables

Table 1: Contribution of partners	9
Table 2: Relation to other activities in the project.....	10
Table 3: Urban platform stakeholders	17
Table 4: Data format standards	21
Table 5: The standards for MAKING-CITY Urban Data Platforms	26

Abbreviations and Acronyms

Acronym	Description
API	An application programming interface (API) is an interface or communication protocol between a client and a server intended to simplify the building of client-side software.
BIM	Building Information Modelling; is a process supported by various tools, technologies and contracts involving the generation and management of digital representations of physical and functional characteristics of places
ICT	Information and Communications Technology
CIP	City Innovation Platform created in the IRIS project.
CKAN	CKAN is a data management system that makes public and private data accessible by providing tools to streamline publishing, sharing, finding and using data.
DCAT-AP	The DCAT Application Profile for data portals in Europe (DCAT-AP) is a specification based on the Data Catalogue Vocabulary (DCAT) developed by W3C.
IoT	Internet of Things
OGC	Open Geospatial Consortium
OUP	Open Urban Platforms (also working group of EIP-SCC)
RDF	Resource Description Framework is used to combine data using URLs as identifiers to link resources/data.
Reference Architecture	A template that offers a common language and support for standards, specifications and patterns, a list of functions and interfaces (APIs) and their interactions with each other.
SCIS	Smart Cities Information System

Executive Summary

Existing ICT Platforms are adapted into Urban Data Platforms for MAKING-CITY, which are an important part of the required ICT infrastructure for cities to monitor and evaluate the effectiveness of the MAKING-CITY project actions and interventions. The adherence of the platforms to open standards ensures interoperability between evaluation frameworks developed in the different cities.

Work Package 5 focuses on the development and implementation of robust monitoring and evaluation protocols, including a full methodology for the monitoring and evaluation of the project actions and interventions that will allow the introduction of future data after the end of the project. Within the present WP and in close collaboration with WP8, links with (SCIS) Smart Cities Information System database will be established. The scope of the monitoring protocol will be twofold, firstly in order to measure the performance of the actions deployed to reach a validation of PED concept and secondly to evaluate the impact at city level. Such protocol will be based on the previous works by CITYkeys and SCIS in order to select a set of Key Performance Indicators (KPIs) and data collection procedures for the common and transparent monitoring as well as the comparability of smart city actions across the cities. All performance data (i.e. KPIs) will be incorporated into SCIS database. At this point, a strong coordination with the lighthouse cities will be required to integrate useful and useable information as open data within the Urban Data Platforms.

Task 5.5 is a cross-cutting activity among WP2, WP3 and WP5 and is in charge of defining a common and open adaptation framework for the ICT developments in order to ensure an adequate data integration towards monitoring and evaluation of the project results.

Subtask 5.5.1: Requirements for the urban platform as DAQ-enabler (Open Specifications, Open APIs and open Data): This subtask will set up the basis for the development of solutions that are interoperable and follow an open specification approach in order to embed these mechanisms in the Oulu and Groningen Urban Platforms, ensuring the collection of the necessary data and information. Available data sources, data formats, data access protocols will be analysed, while confidentiality, privacy and security issues are prioritized. The result will be the description of all data sets that will be needed as input for the data collection system and their aggregation levels. Functional requirements, software architecture and data structures will be developed.

Subtask 5.5.2: Supervising of fulfilment of requirements of open specification and open data: In this second cross-cutting task, an interoperability test plan will be established from a harmonised approach in the demos. It will be demonstrated that the new modules developed to improve the Urban platforms are interoperable, ensuring that these can interact in an appropriate manner with the other platforms/software or software components and that information exchanged is correct and valid.

This deliverable describes the adherence to open standards for the Urban Data Platforms in support of data acquisition and publishing for data collection, monitoring and new services.

1 Introduction

1.1 Purpose and target group

The Urban Data Platform for MAKING-CITY should enable data collection, monitoring and especially reporting of results. The common open specification, as described in this document, ensures adequate interoperability and alignment towards monitoring and evaluation of the project results.

This report constitutes Deliverable “D5.9 ICT-City Platforms: common open specifications” which is the main outcome of the “Task 5.5 ICT Urban Platform”.

The main objective of the deliverable is to provide an overview of the relevant standards and common open specification that may be followed for the Urban Data Platforms as part of the MAKING-CITY project.

This document is intended for the ICT partners to give guidance on the requirements for their platforms as they need to provide implementations of the listed specifications. Other partners can use this document to determine how they will set up and use the Urban Data Platform in their city to share data.

Chapter 2 describes the concept of an Urban Data Platform and introduces related European projects. In chapter 3 the components of an Urban Data Platform are explained together with possible standards that can be used for their implementation. Finally, in chapter 4 the specific standards applicable for the MAKING-CITY project are listed.

1.2 Contribution partners

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

Table 1: Contribution of partners

Partner nº and short name	Contribution
03-GRO	Provide requirements for data exchange.
09-CGI	Collect relevant standards
10-SB	Provide requirements concerning storage of metered data.
13-OUK	Provide requirements for data exchange.
20-VTT	Determine selected standards and discuss implementation details with CGI.
32-R2M	Review of the deliverable.
Others	General requirements for data exchange.

1.3 Relation to other activities in the project

The following Table 2 depicts the main relationship of this deliverable to other activities (or deliverables) developed within the MAKING-CITY Project and that should be considered along with this document for further understanding of its contents.

Table 2: Relation to other activities in the project

Deliverable/ Action n°	Relation
D2.8 / D2.19, D3.8 / D3.19	<i>Adaptation of Oulu ICT platform and Adaptation of Groningen ICT platform.</i> Describe the adaptation and integration with existing ICT platforms to form Urban Data Platforms for the respective lighthouse cities.
D2.9 / D2.20 / D2.12 D3.9 / D3.20 / D3.21	<i>Services and Modules for Oulu ICT Platform and Services and Modules for Groningen ICT Platform.</i> Describe the services and modules built on top or integrated with the Urban Data Platform for the respective lighthouse cities.
D5.5	<i>Data sets: Requirements, collection and protection</i> Describes the data stored in the Urban Data Platform.
D5.6, D5.7, D5.8	<i>Guidelines for definition of Monitoring Programmes, Oulu Monitoring Programme, Groningen Monitoring Programme</i> The monitor programmes will make the measurements, at least partially, available using the standards described in this deliverable.
D5.2/D5.14	<i>Project level indicators</i> Where possible the Urban Data Platform will facilitate calculation of the project level indicators by providing the necessary input data. Additionally the indicators themselves will be available via the Urban Data Platform.
WP2 – Actions 5, 13, 18, 26	<i>Smart control in buildings 1,2,3 and 4 and wireless advanced control in Arina.</i> The buildings will be fitted with a wireless sensor network which monitors indoor air quality (Temperature, humidity, CO2, pressure) and operates heating, ventilation and lighting. It also monitors the energy consumption (heat and electricity) and operates as a demand response control unit. The data from the consumption will be collected to a common database with the local high speed network (Action 34).
WP2 – Action 34	<i>High speed data transfer network.</i> This network will cover the whole area, it is used both for control and data aggregation. The data network will be used in order to control both electricity and heat management. It also serves the people by delivering online data of the energy balance thus improving the energy awareness of the inhabitants (Actions 5, 13, 18 and 26). Third function of this network is to store data for learning, verification and documentation purposes.
WP3 – Action 35	<i>Open urban platform adaptation.</i> The municipality of Groningen is connected to the Civity Dataplatform which is a wide used open data platform in the Netherlands. The most important goal of this platform is to share and use the potential of (open) data by governmental, commercial and knowledge institutes. Dataplatform is based on CKAN, FIWARE and Drupal software (open source) which allows the downloadable of datasets as well as programmatic access by API's (also IoT API's). To ensure the findability of the datasets, the metadata and download link is automatically harvested by national open data sites and subsequently publicised. There are no technical restrictions

	<p>preventing the input of data (possibly after conversion) from the project into this platform.</p> <p>Within MAKING-CITY project, data integrity, authorisation and privacy will be embedded in the platform. Measures that guarantee data protection and security will be integrated from the start of the project to comply with privacy legislation (GDPR). Data access will be implemented on using different user authorisation levels. Data collected from PEDs will be aggregated for monitoring and data analysis.</p>
WP3 - Action 37	<p><i>Integration of new services to the data platform.</i> New services will be developed and integrated in the Groningen Urban platform to use and share the results generated in the project related to the monitoring of PEDs. These services will be focused in the improvement of the city operation and in the investment and planning of positive energy buildings.</p>

2 Existing open specification frameworks

This section describes the reference architectures that forms the common open specification for the urban data platforms created in the Lighthouse cities based on existing ICT platforms. Many frameworks for urban platforms exist and have been developed as part of previous Lighthouse projects. This section is the result of the analysis of several of these projects.

2.1 Urban Platform References

This section lists the projects analysed for the MAKING-CITY specifications framework. The project descriptions are limited to the goals for their urban platforms.

2.1.1 EIP-SCC Urban Reference Architecture and ESPRESSO

All other analysed Lighthouse projects reference the EIP-SCC Work Stream 2 and ESPRESSO.

The European Innovation Partnership on Smart Cities and Communities (EIP-SCC) is a major market-changing undertaking supported by the European Commission bringing together cities, industries, SMEs, investors, researchers and other smart city actors. (EIP-SCC, 2019) It has published a Urban Platform Management Framework (BSI, 2017) which includes definitions for terminology like “Urban Platform”, which is used throughout this report. In collaboration with the ESPRESSO project, it created a reference architecture and design principals for Urban Platforms (EIP-SCC, 2017)

The main target of the ESPRESSO project is to ensure the interoperability of Smart City solutions. This will help cities avoiding entry barriers or vendor lock-in through promoting common meta-data structures and interoperable (open) interfaces instead of proprietary ones. (ESPRESSO Project, 2019)

The ESPRESSO reference architecture created based on the collaboration with EIP-SCC Work Stream 2:

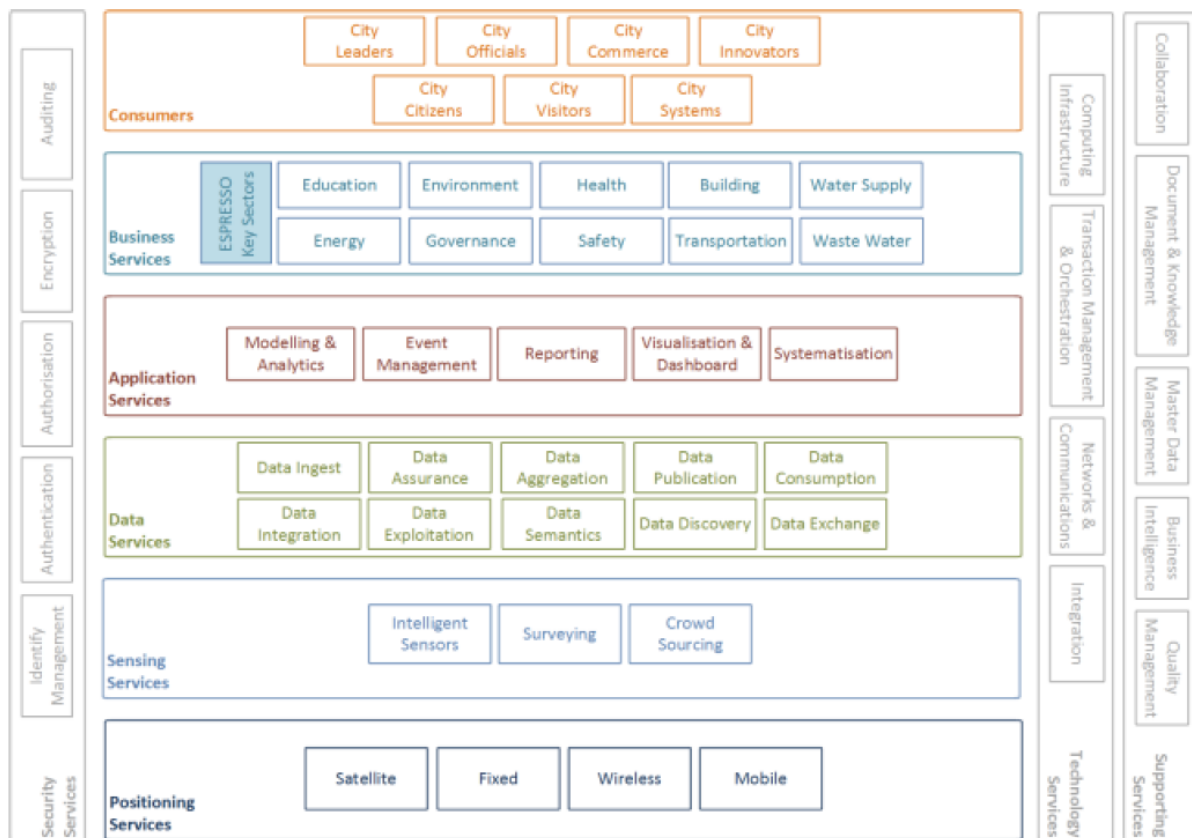


Figure 1: ESPRESSO reference architecture (ESPRESSO, 2017)

2.1.2 Urban Platforms in Lighthouse Projects

Deliverables of the following Lighthouse projects have been analysed to gain insight into existing Smart City and Urban Platforms:

- SynchroniCity created a good overview of existing Smart City standards and implementations at that time, including FIWARE, which is discussed below. (Synchronicity, 2017)
- mySMARTLife open framework – uses a selection of open specifications to create a project specific framework similar to MAKING-CITY. (mySMARTLife, 2017)
- IRIS – City Innovation Platform – Reference Architecture for Smart City platforms focused on providing open interfaces and a platform that supports innovation in a city. (IRIS, 2018a)
- RUGGEDISED – Smart Open Data Platform – The project creates a model for smart cities focusing on sustainability. (RUGGEDISED, 2019)

The architectures used by urban platforms for smart cities in these Lighthouse projects have converged and contain large overlap in the common open specifications and reference architectures they describe. The reference architecture created for the IRIS project is the most recent and detailed and provides a useful framework to discuss the Urban Data Platform architecture and standards in this document.

Similar to the platform needed for MAKING-CITY, the IRIS project used the platform “to collect, manage and exchange data for the development of new applications and services” in a city. (IRIS, 2018a)

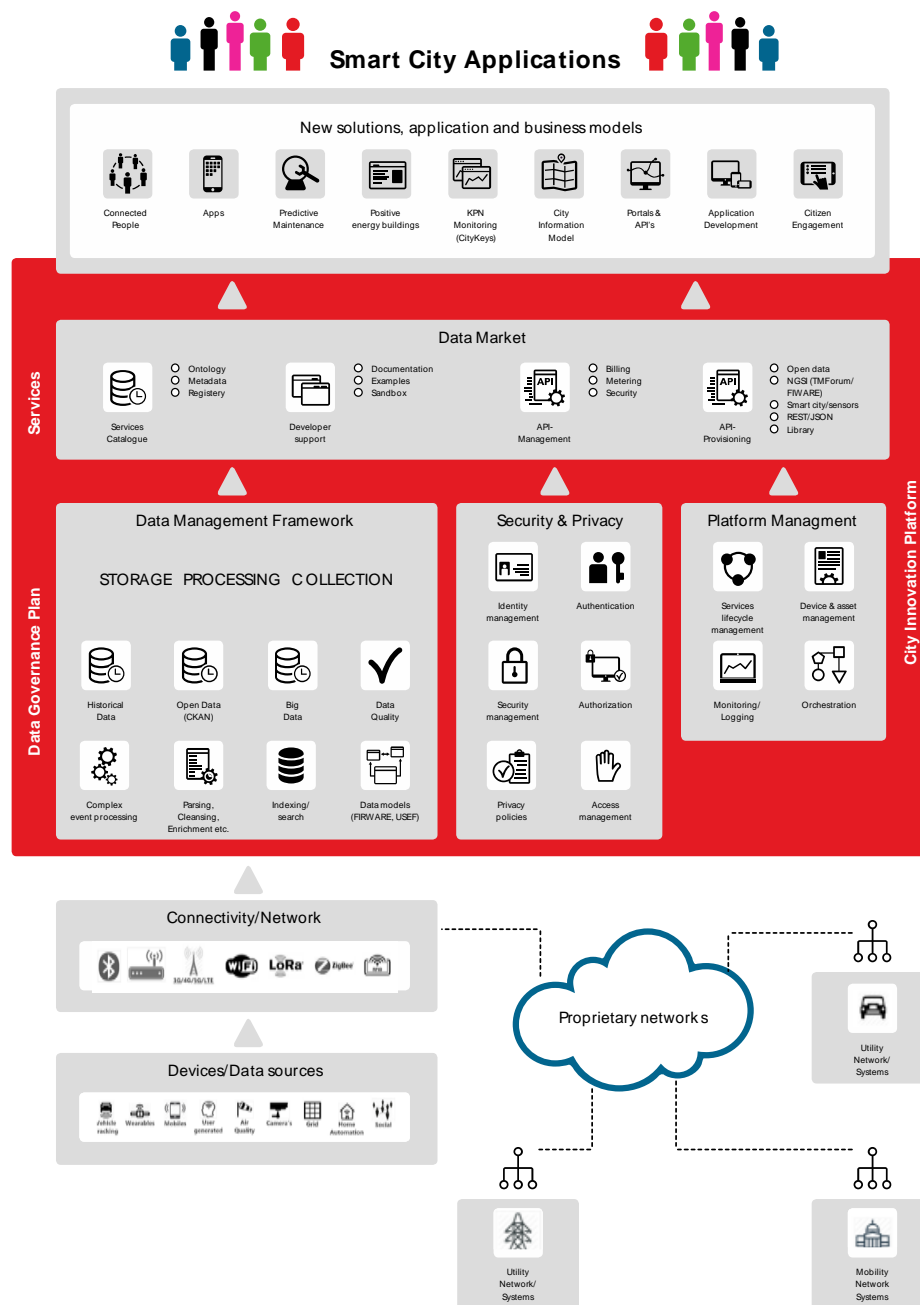


Figure 2: IRIS City Innovation Platform (IRIS, 2018a)

The City Innovation Platform comprises five main components, as shown in figure 2. These components are:

- Data management framework
- Data market
- Security and privacy
- Platform management
- Proprietary systems connectivity (federated solution)

Each of these components and their related standards are discussed in detail from the perspective of MAKING-CITY in the next sections.

2.2 MAKING-CITY Urban Data Platform reference architecture

Combining the reference architectures of other Lighthouse cities with the requirements specific to the MAKING-CITY project leads to the architecture for the Urban Data Platform shown in Figure 3. It shows the Urban Data Platform central to the project for collecting information from disparate sources like building measurements and Charge Point Management Systems (CPMS).

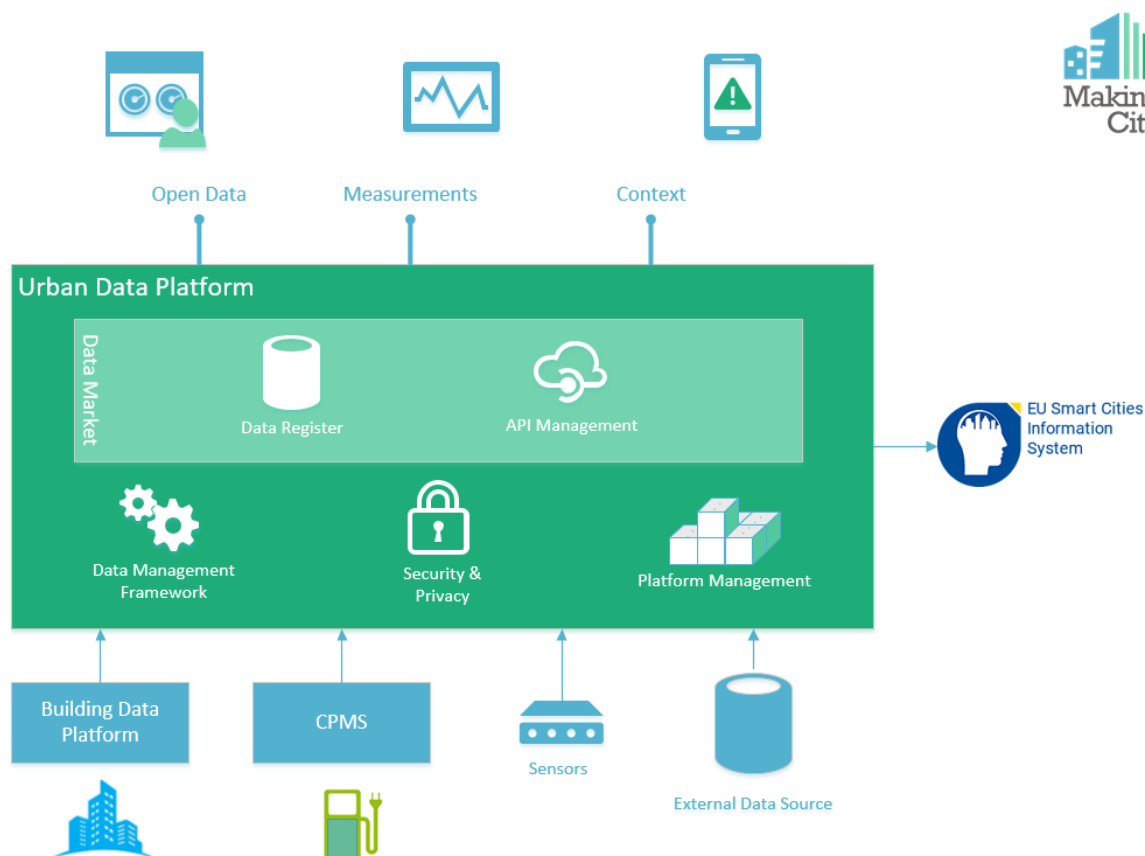


Figure 3: MAKING-CITY Urban Data Platform reference architecture

This section gives a high-level description of each to the main components in the context of the Urban Data Platform for the MAKING-CITY project. The architecture, including the definition of the main components, is based on the reference architecture created in the IRIS-project. (IRIS, 2018a)

The rest of this document will go into the chosen standards for the interfaces ensuring interoperability between different implementations of this reference architecture.

2.2.1 Data management framework

The core of the platform has to receive and store large amounts of data. Initially, for MAKING-CITY, the data is limited to measurements and calculated indicators, but additional data sources and formats can be expected during the project.

The platform will focus on the OGC-standards (<http://www.opengeospatial.org/standards>) in this area concerning data formats/models.

The main purpose of this component is managing the data workflow: data is received from connected platforms or devices, it needs to be processed, possibly translated and finally stored in a way that enables exploitation or sharing via the Data Market component.

2.2.2 Data Market

A Data Market is designed as an online store for different data products and types (open, commercial datasets and information products) from different sources/organizations and aimed at different users. Data can be made available as download, API or other arrangements. Data Markets are aiming to facilitate data consumers, like developers, journalists or consultancy agencies, to create new business opportunities. MAKING-CITY does not have requirements for data monetization, but the concept of publishing data sets in a user-friendly manner similar to an online store is relevant for Open Data as well.

2.2.3 Security and privacy

Data should be stored securely and privacy concerns need to be taken into account throughout the system. This component contains basic functionality like authentication, but also highlights cross-cutting concerns such as data authorization (limiting access to data where needed).

2.2.4 Platform Management

Platform Management includes all functionality needed to manage the platform infrastructure itself as well as configure connectivity of (new) devices sending in data.

2.3 Reusable components

Several of the Lighthouse projects mention existing components they have integrated into their architectures. They already implement widely used standards and are evaluated for use in the Urban Data Platform implementations for cities as part of the MAKING-CITY project.

2.3.1 FIWARE

Both SynchroniCity and the IRIS CIP reference architecture lean heavily on FIWARE. FIWARE is an open source platform intended to provide the software infrastructure needed to support smart applications in multiple sectors. Particularly for smart cities FIWARE provides components that allow acquiring and harmonizing data coming from different IoT devices or external systems owned by the city. Such data is published on a data hub (context broker) which contains a uniform view of the status of a city. The FIWARE Context Broker offers a REST API, which allows applications and other services to manage consume and subscribe to all the data generated by the city. (FIWARE, 2019)

With the context broker in place, different components can be plugged in to add functionality. Specifically historical data is not stored in the context broker. Documentation is available to setup extensions. This includes big data storage to support analysis of historical data, but also extensions for the publication of city data by integrating with CKAN.

2.3.2 CKAN

Many cities, including Groningen, use CKAN (<https://ckan.org/>) for their open data portal. CKAN is a data management system that makes public and private data accessible by providing tools to streamline publishing, sharing, finding and using data. For this reason, several Lighthouse projects have chosen to integrate it into their architectures.

2.4 MAKING-CITY requirements & stakeholders

The evaluation framework of MAKING-CITY project consists of 2 parts: a monitoring programme and project KPIs. Together they enable measuring the impact of the project in each of the partner cities. Several of the indicators can be calculated based on measurements, which are part of the monitoring program as well. The measurements need to be collected and stored. For example energy consumption and production in a PED will be measured for several buildings to calculate energy-related performance indicators.

To store measurements, perform calculations and share the resulting information a platform is needed. As the platform is intended to bring together and integrate data flows within and across the city, it also fits the definition of an Urban platform mentioned in the EIP-SCC Urban Platform Management Framework (BSI, 2017).

The City Innovation Platform reference architecture has identified stakeholders around an Urban Platform (IRIS, 2018b) that we can use to group the requirements within the MAKING-CITY project.

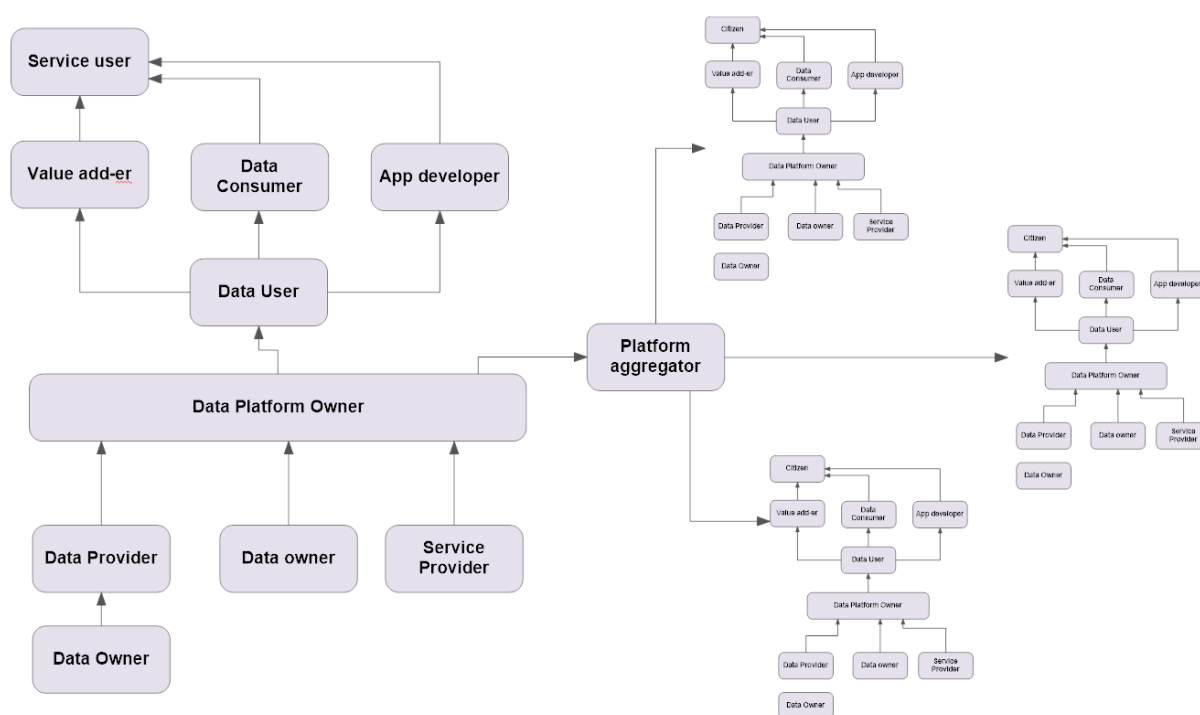


Figure 4: Stakeholders in City Innovation Platform ecosystem (IRIS, 2018b)

For the Urban Data Platforms in the MAKING-CITY project the number of stakeholders is more limited, but it is useful to identify them and to determine the requirements they will have.

Table 3: Urban platform stakeholders

Stakeholder/Role	Main Demand	Examples in MAKING-CITY
Data Provider	Connect and upload data	Groningen: Sustainable Buildings for energy measurements

		Oulu: VTT
Data Owner	Control over data	Building owners and municipalities.
Service Providers	Availability of data guarantees and secure infrastructure	Oulu: VTT will provide energy management services
Data User	Data reliability and quality. Means to access the data	Groningen: TNO for simulations
Data Platform Owner	Maintainability, Service Level Agreements and compliance with laws, regulations and privacy rules	Groningen: CGI Oulu: VTT
Data Consumers	Understanding of meaningful services and understandable data	Groningen: data will be used by the citizen engagement initiatives
Data Value-adders	Standardized data, marketplace for data and licensing models that support the creation of new business models	Stakeholders not part of MAKING-CITY
App Developers	Service level agreement, data quality and licensing models that support the creation of new business models.	Stakeholders not part of MAKING-CITY
Platform Aggregators	Standardized data to enable exchange with other platforms	
Policy Maker	Compliance with rules, laws and regulations like GDPR.	Municipalities

Within MAKING-CITY, not all stakeholders or roles are represented, which reflects the limited scope of the platform within the project compared to the City Innovation Platform reference architecture.

2.5 KPI standardization

2.5.1 SCIS

The Smart Cities Information System (SCIS) is a knowledge platform encouraging exchange of data, experience, know-how and collaboration on smart cities to ensure a high quality of life and a clean, energy-efficient and climate friendly living environment for the citizens (SCIS, 2019). From the point of view of lighthouse projects, the most typical use of SCIS is its database as reporting of monitoring data to that database is mandatory for all.

In SCIS, the current approach for data collection is through individual project data collection done by monitoring experts, and this information is periodically updated in the self-reporting tool (SCIS, 2018b). The aim of the data collection is to allow the comparison of results of the projects (SCIS, 2018a). In data collection, a distinction is made between new systems and renovations of existing systems. The evaluation process uses a bottom-up approach, collecting data from small Energy Supply Units (ESU), buildings and implemented mobility and ICT solutions at unit level. These are aggregated in cases where

the objective is to evaluate the energy performance of a whole neighbourhood or city. Data quality in SCIS is ensured with:

- Compliance with SCIS data requirements
- Documentation on metadata (such as time of measurement, unit, application area...)
- Adjustments to apparently implausible data is discussed and checked with SCIS

Indicators calculated in the Urban Data Platforms will be shared with the SCIS database.

2.5.2CITYkeys

CITYkeys developed and validated, key performance indicators and data collection procedures for the common and transparent monitoring as well as the comparability of smart city solutions across European cities (Bosch, 2015). As the main goal of the Urban Data Platform for MAKING-CITY is to calculate KPIs, it is worthwhile to look at the standards CITYkeys used for data collection and indicators.

3 Interoperability standards

This section describes the relevant data standards found in the analysis of existing Lighthouse projects as described in the previous section. The standards ensure interoperability of multiple implementations of the Urban Data Platform when they choose disparate technology for the implementation of platform components.

Data standards is a wide subject, so it is important to clarify where they are applicable in the platform:

1. Data models – The structure of the data and meaning of the values. Will be discussed in the context of the Data Management Framework as they are closely related to the storage and querying stored data.
2. Data formats – The export or file formats. Not necessarily the internal data format, but the format in which the data can be exported. Discussed in the context of the Data Market where data can be downloaded in these formats.
3. API's – Application Programming Interfaces. The interfaces used by other systems to interact with the data. Will be discussed in the context of the Data Management Framework as they are closely related to interaction with the data.

3.1 Data Market

The Data Market component of the CIP-architecture is to facilitate the use of data by all kinds of organisations: government, business, but also individual developers. For MAKING-CITY, the main role will be in sharing the data with partners and publishing results of the project as Open Data.

As described in the previous section, the Data Market has three functions:

1. It provides a point of discoverability and comparison for data, along with indicators of quality and scope.
2. It offers ready to use data (high quality, high usability)
3. It provides an economic model for broad access to publish and consume data and create new business models.

(IRIS, 2018a)

In the context of MAKING-CITY the last function for an economic model is not expected.

3.1.1 Register

The Data Market should provide an overview of all available data within the platform or as provided by external services in a Data Register.

This register can be implemented using CKAN (<https://ckan.org/>), which is already used by many cities, including Groningen for their open data portal. CKAN is a data management system that makes public and private data accessible by providing tools to streamline publishing, sharing, finding and using data. CKAN can be used in different ways. For example, the Dutch National Open Data Portal (<https://data.overheid.nl>) uses CKAN as a register only. No data is stored in that CKAN implementation, but it shows the metadata (based on DCAT-AP standard) and refers to the location of the original source. The Data platform used by the City of Groningen, is also based on CKAN (<https://groningen.dataplatform.nl/>), but stores data as well and provides an API to connect to the data.

The register will contain links to the actual data, either stored in the platform itself or somewhere else. The data can be downloaded directly in a predefined format or sometimes accessed via an API. Downloaded data will have a structured machine-readable format.

Some of the open formats available are listed in the table below.

Table 4: Data format standards

Format	Description
JSON	JavaScript Object Notation. Open standard format that is human-readable, originally used for asynchronous browser-server communication. Widely used format derived from JavaScript.
XML	Widely used data exchange format. Very verbose, with support for schema validation.
CSV	Comma separated files. Very compact format, but requires the data to be a flat table. No hierarchical data is supported. Accurate adherence to the structure for every line is very important, as an issue can cause the whole file to become unreadable.
GeoJSON	Open standard format for representing simple geographical features, based on JSON.
TXT	Plain text. Used for unstructured data, not suitable for data sets.
RDF	Resource Description Framework is used to combine data using URLs as identifiers to link resources/data. This provides a convenient way to directly interconnect existing data on the Web. It can be serialized in many formats including JSON (JSON-LD) and XML (RDF/XML).

3.1.2 API Management

The Data Market is also responsible for the management of any APIs in the Data Management Framework. API management has to ensure that exposed APIs are consumable, secure, and available to consumers in conditions agreed upon in the APIs terms of use. The main components of API Management are:

- Registry – Inventory of available API's. Can be fulfilled by the Data Market Register described above.
- Gateway – All API's are accessible only through the gateway, which can enforce throttling and security policies.
- Publishing tools – Tooling to register API's.
- Developer portal – Facilitate the consumption of an API. Includes helpful tools and other resources to build new services on the offered API. Can also be part of the Data Market Register.
- Reporting and analytics – Information on the actual usage of the API.

(IRIS, 2018b)

The most used standard to describe an API is the OpenAPI Specification (https://en.wikipedia.org/wiki/OpenAPI_Specification). It provides a machine-readable description of

an API, which can be used in all the API Management components as well as for a description of the API for external consumption.

3.2 Data Management Framework

The data stored in the Data Management Framework is exposed through an API or as downloadable files. To ensure interoperability between platforms it is important that data in different platforms have the same structure and a well-understood meaning. This section will describe the data modelling standards for the urban data collected and stored in the platform. Each section describes different types of data, which will be exposed using different API's, with different specifications. This enables using a suitable data model for each.

3.2.1 Building

Building information modeling (BIM) is a process supported by various tools, technologies and contracts involving the generation and management of digital representations of physical and functional characteristics of places. Building information models (BIMs) are computer files (often but not always in proprietary formats and containing proprietary data) which can be extracted, exchanged or networked to support decision-making regarding a built asset. BIM software is used by individuals, businesses and government agencies who plan, design, construct, operate and maintain buildings and diverse physical infrastructures, such as water, refuse, electricity, gas, communication utilities, roads, railways, bridges, ports and tunnels.

3.2.1.1 ISO 19650

ISO 19650 is based on British standard BS 1192 and public standard PAS 1192-1, which the ISO said has helped reduce user construction costs by 22%. The organization plans to develop and release additional standards including a Part 3 on managing the operational phase of assets and a Part 5 dealing with BIM security, digital built environments and asset management.

BIM is still not complete and the existing part covers **concepts and principles** and **delivery phase of the assets**. Part 3 is on its way, and it will be focused on managing the operational phase of assets while Part 5 will deal with asset management, digital built environments, and BIM security.

These parts will be published in the future and they will contain information that could have been used in Making City project. Since this is not possible at the moment we may return to this after some new relevant information is available. Applying the published part of the standard does not bring any benefit to the project.

3.2.2 City

Information about the city helps to understand any measurements and indicators stored in the platform. Part of this description is the "City Information Model" (CIM). It is used to model, build and visualize buildings, bridges and streets. This enables visualizing the physical city through its digital twin in a 3D model of the city. (IRIS, 2018a)

3.2.2.1 CityGML

CityGML and Land/InfraGML are international Open Geospatial Consortium (OGC) standards for the representation and exchange of semantic 3D city, landscape and infrastructure models. The data model behind CityGML is based on the ISO 19100 standards family and is implemented as an application schema for OGC's Geography Markup Language (GML). Further extensions, called Application Domain Extensions (ADE), are available, for example for energy modelling purposes. ADEs such as the Energy

ADE4 and the Utility Network ADE5 can be used to describe energy relevant parameters of the city directly in the CityGML data model. A data model schema specification is available for the XML data format.

3.2.2.2 FIWARE NGSI-LD

Another data model for context information, more focused on real-time IoT-data, is FIWARE NGSI-LD. The main elements are context entities, attributes and metadata. It has different data models for different information domains in the city. A few examples:

- Air Quality
- Civic Issue Tracking
- Parking
- Building – general information about a building like location, number of floors and opening hours for using is smart management/automation scenarios.
- Indicators

A full list can be found at <https://fiware-datamodels.readthedocs.io/en/latest/index.html>

These data model have specifications available in JSON data format.

3.2.3 Measurements / History

Many Smart City projects, including MAKING-CITY, collect measurements. The current or latest value of a measurement can be useful in the context of information about the city, but for most of the analysis the history of these measurements is required. These measurements should be stored or at least accessible as a sequence of data points in time order or 'time series'.

3.2.3.1 SensorThings API

The SensorThings API provides an open, geospatial-enabled and unified way to interconnect the Internet of Things (IoT) devices, data, and applications. The Sensing part of this API provides a standard way to manage and retrieve observations and metadata from heterogeneous IoT sensor systems.

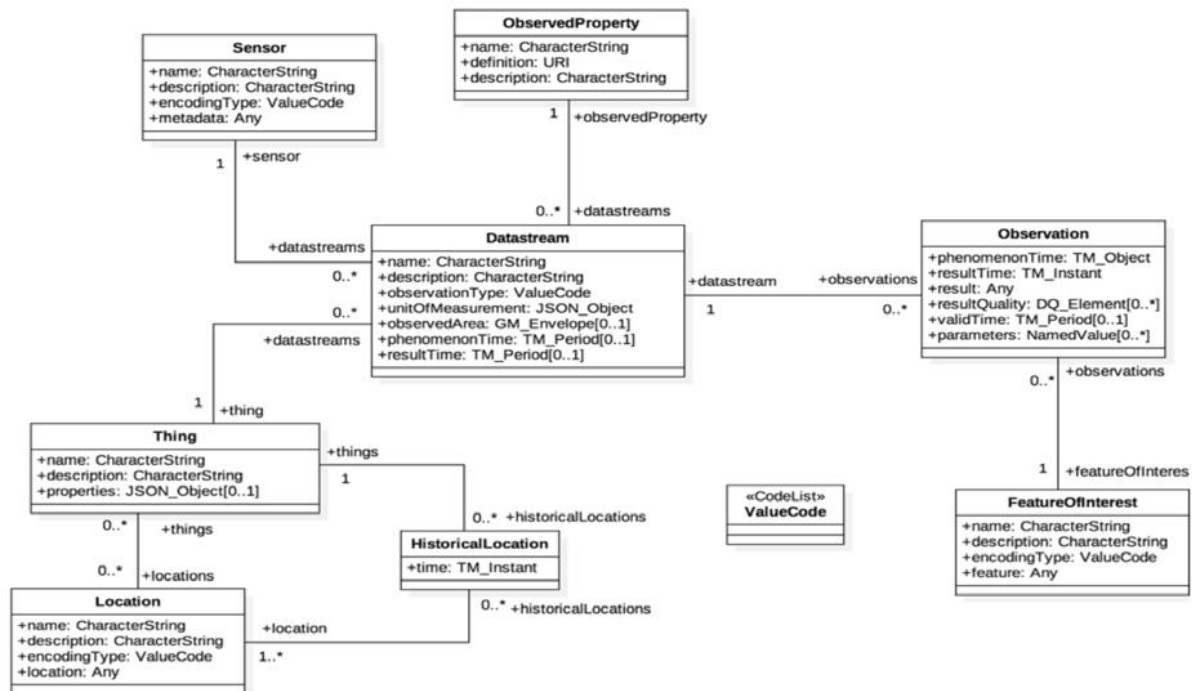


Figure 5: SensorThings API entities (OGC, 2019)

3.2.3.2 FIWARE ngsi-tsdb

As mentioned in the section about Context information the FIWARE NGSI-LD data models are also intended for IoT data, but not all data models of that standard keep track of historical values. To enable storing and accessing history for attributes of a FIWARE NGSI-LD data model, the FIWARE ngsi-tsdb standard can be used. As the name suggests the standard implementation, suggested by FIWARE, uses a time series database to store the history as a time series (<https://quantumleap.readthedocs.io/en/latest/>).

3.3 Security and Privacy

When storing data both security and privacy are important aspects for all components. The platforms will need to comply with the European General Data Protection Regulation (GDPR). The GDPR requires:

- the use of Privacy-by-design (PbD), Privacy-by-default and Privacy Impact Assessment (PIA) in the design of ICT systems involving personal data processing,
- the nomination of data protection officers for all public authorities and companies processing personal data for more than 5000 data subjects.

The platform offers capabilities to secure, or limit access, to data, but compliance will mostly depend on processes and organisational policies around the data stored in the platform.

As the platform is, in the scope of MAKING-CITY, only intended to store project measurements and indicators, it is important that the cities, as owners of the data, ensure that a Privacy Impact Assessment is performed to identify any Personal Identifying Information (PII).

The analyses of other Lighthouse project has not resulted in any standards, but all do specify some form of Access Control, which is needed when not all stored data is classified as Open Data.

3.4 Platform management

The final component is Platform Management. It contains functionality for the management and deployment of parts of the platform. This can include device management for any connected devices sending in data or deployment of new versions of parts of the platform. No common open specifications are prescribed for MAKING-CITY in this area as Platform Management is intended for the platform owner and not accessible to other consortium partners.

3.5 Connectivity

Connectivity with other platforms, or as the CIP-architecture calls it: a federated network of platforms, is an expected outcome of an Urban Platform. Federated means data is exchanged in two directions, each platform remains autonomous and the data remains under control of the owner of the platform, but the platform must comply with agreements regarding data-exchange. This creates an ecosystem of partners (data-owners, platform suppliers, app-builders, service providers, cities, etc.) who can easily collaborate on data.

In general, each connected platform requires a different approach and agreements. This section describes some examples of connectivity necessary for the MAKING-CITY project and any relevant open standards that can be used.

3.5.1 Buildings

For Groningen: Partner 10 Sustainable Buildings BV is responsible for the measurements about a building, including installing the necessary measuring equipment. They have a platform for collecting and processing these building measurements. To ensure fast transfer of these measurements, a streaming interface will be used based on Apache Kafka. The data format will be JSON and the data model will be proprietary.

For Oulu the Energy Management Platform created by VTT will be responsible for collecting the measurements and also for making this data available to other stakeholders in a standardized way.

3.5.2 Charge points

For Groningen the new charge points will be connected to a CPMS (Charge Point Management System) which will expose relevant information. This platform owned by the operator of these charge points will provide an API supporting JSON over HTTP and a possible data model standard is the Open Charge Point Protocol (OCPP).

4 Open specification of the MAKING-CITY Urban Data Platform

This section describes the standards of the open specification for Urban Data Platform in the context of MAKING-CITY. These standards enable access to the data for creation of new services in the rest of the project.

Table 5: The standards for MAKING-CITY Urban Data Platforms

Domain	Standard	Links	When applicable
Data Market	CKAN	Web site	<p>To store and publish Open Data.</p> <p>Best suitable for infrequently changing information. Ensure that sufficient metadata is provided to understand the context of the data set.</p> <p>Examples from the MAKING-CITY project may include aggregated yearly metrics and project indicators.</p>
Data Management - Building Context	ISO 19650	Web site	To share detailed building information.
Data Management - City Context	CityGML	Web site	To share detailed geographical or 3D models of the city.
Data Management - Measurements Specifically geospatial related sensor data, or telemetry as time series. Often related to IoT.	SensorThings API	Web site Specification	<p>To share time series data about a location.</p> <p>Can be large amounts of detailed data. The API provides a way to select only the required information from all the collected data.</p> <p>Besides measurements, calculated information about the locations can be shared with this same standard.</p>

4.1 Lighthouse cities

4.1.1 Oulu

City of Oulu has several digital services for the citizens. Most of them are related to social wellbeing and municipal services. Making city project partners like Oulun Energia and Sivakka are having their own services to keep track of energy distribution and production. These databases are not for public use. However, in Making City the data relevant to the project will be collected from these sources and will be available for project members and also for SCIS reporting. VTT will also open some other data repositories for online monitoring of individual buildings. These buildings are located to Oulu PED area. So all buildings in PED area will have online monitoring and data collection. This data will be collected on minute basis and it will be visualised in the PED project server

(<https://makingcity.vtt.fi/authtest/auth/index.html>). The test version of the database is already running and collecting data from the grocery store in the area. During the second and third year of the project the remaining buildings will be added to the system.

The UI for the database and PED-monitoring will provide tools to inspect the area on system level, building level and PED level.

The software and tools are based on open source software (PYTHON, MARIADB) and JSON/REST interfaces. So the results can be spread and used by lighthouse and follower cities without any extra licence fees.

BIM modelling has not been used in Oulu PED area in modelling or planning, and the stakeholders are not using it either. Thus bringing it in to the project will not have any added value to the implementation.

See deliverable *D2.9/D2.20/D2.21 Services and Modules for Oulu ICT Platform* for more information about how the standards are used to enable services in Oulu.

4.1.2 Groningen

Groningen has been using CKAN for the Groningen Open Data portal already and selected results will be published here. For the sharing of metrics as well as the original measurements within the consortium an interface adhering to the SensorThings API standard will be added.

Standards for CityGML and BIM are not adopted in the Groningen Platform. 3D Representations of the City are actively investigated by the City of Groningen, but outside of the scope of the MAKING-CITY project. We may incorporate the result of this investigation in future deliverables.

Since information related to BIM is not shared as part of the physical design and implementation in the PEDs nor in the data reported to other stakeholders, there is no requirement nor added value for adapting this standard in the platform.

See deliverable *D3.9/D3.20/D3.21 Services and Modules for Groningen ICT Platform* for more information about how the standards are used to enable services in Groningen.

4.2 Follower Cities

Before setting up an Urban Data Platform for a follower city consider two aspects should be considered:

- Evaluate current platforms and data stores and their suitability for integrating into the Urban Data Platform. Especially evaluate the standards used for interfaces.
- Investigate the requirements and use cases and prioritize them.

This evaluation should give insight in the data and technology that is already available. Then consider what data about the city should be collected to monitor a PED, what data needs to be shared and with whom. Select existing platforms based on the specified standards or require implementation of the standards for new platforms. If a standard is not applicable as data is not available or will not be shared there is no obligation to implement an interface or store using the standard until it is needed.

5 Conclusions

Based on work from previous projects around Smart Cities and Open Urban Platforms, a number of relevant standards and reference architectures for the Urban Data Platforms in the MAKING-CITY project have been identified. The final selection of standards has been done based on the requirements of the MAKING-CITY project and existing Open Data strategies of the Lighthouse cities resulting in the specification and reference architecture for the MAKING-CITY Urban Data Platform. The selection of these standards is only the starting point. Creation of Urban Data Platforms and integration of services will verify if these standards enable the interoperability needed to facilitate and monitor PED creation. Deliverables D2.8 and D3.8, about adaptation of existing platforms, and D2.9 and D3.9, about the services and modules for these platforms will cover that for each of the two lighthouse cities, Oulu and Groningen.

Bibliography

- Bosch, P. J. (2015). *Deliverable 2.1 Definition of data sets. CITYkeys report 2.1*. Retrieved from CITYkeys: <http://www.citykeys-project.eu/citykeys/resources/general/download/CITYkeys-D2-1-Definition-of-data-sets-WSWE-AJENTU>
- BSI. (2017). *EIP-SCC Urban Platform Management Framework - Enabling cities to maximize value from city data*. Retrieved from https://eu-smartcities.eu/sites/default/files/2017-09/EIP_Mgnt_Framework.pdf
- EIP-SCC. (2019). *The European Innovation Partnership on Smart Cities and Communities*. Retrieved from <https://eu-smartcities.eu/>
- ESPRESSO Project. (2019). *ESPRESSO Project*. Retrieved from <http://espresso-project.eu/>
- EU Smart Cities Information System (SCIS). (2018a). *Monitoring KPI Guide D23.1*. Retrieved from Smartcities Information System: <https://smartcities-infosystem.eu/library/resources/scis-essential-monitoring-guides>
- EU Smart Cities Information System (SCIS). (2018b). *Smart Cities Information System Self-reporting guide*. Retrieved from <https://smartcities-infosystem.eu/library/resources/scis-essential-monitoring-guides>
- EU Smart Cities Information System (SCIS). (2019). *About the Smart Cities Information System (SCIS)*. Retrieved from Smartcities Information System: <https://smartcities-infosystem.eu/content/about-smart-cities-information-system-scis>
- FIWARE. (2019). *What is FIWARE?* Retrieved from <https://www.fiware.org/about-us/>
- IRIS. (2018a). *D4.2 Functional & technical requirements for integrated, interoperable and open solutions, standards and new business models*. Retrieved from Iris Smart Cities: https://irissmartcities.eu/sites/default/files/documents/d4.2_functional_and_technical_requirements_for_integrated_interoperable_and_open_solutions_standards_and_new_business_models.pdf
- IRIS. (2018b). *D4.4 Document with technical solution reference architecture for CIP components, standards and new business models*. Retrieved from Iris Smart Cities: https://irissmartcities.eu/system/files/private/irissmartcities/d4.4_document_with_technical_solution_reference_architecture_for_cip_components_1.2.pdf
- OGC. (2019). *OGC SensorThings API Part 1: Sensing*. Retrieved from <http://docs.opengeospatial.org/is/15-078r6/15-078r6.html>
- Synchronicity. (2017). *Synchronicity Reference Architecture for IoT enabled smart cities (D2.1)*.