ETSI TR 103 506 V1.1.1 (2018-09)

TECHNICAL REPORT

**SmartM2M;
SAREF extension investigation;
Requirements for Smart Cities**

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Smart Machine-to-Machine communications (SmartM2M).

Modal verbs terminology

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1 Scope

The present document specifies the requirements for an initial semantic model for the smart cities domain based on a limited set of use cases and from available existing data models. The present document has been developed in close collaboration with AIOTI, the H2020 Large Scale Pilots and with ETSI activities in the smart cities domain. Further extensions are envisaged in the future to cover different aspects in the smart cities domain, for example focusing in public equipment. The associated ETSI TS 103 410-4 [i.9] will define the ontology extension (i.e. the semantic model) for the smart cities domain based on the requirements and use cases specified in the present document.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] European Commission and TNO: "Smart Appliances REFerence ontology (SAREF)", April 2015.

NOTE: Available at http://ontology.tno.nl/saref.

[i.2] European Commission and TNO: "D-S4 Final Report - SMART 2013-0077 - Study on Semantic Assets for Smart Appliances Interoperability", March 2015.

NOTE: Available at https://sites.google.com/site/smartappliancesproject/documents.

[i.3] ETSI TS 103 264 (V2.1.1) (03-2017): "SmartM2M; Smart Appliances; Reference Ontology and oneM2M Mapping".

[i.4] ETSI TR 103 411 V1.1.1 (2017-02): "SmartM2M; Smart Appliances; SAREF extension investigation".

[i.5] ETSI TS 103 410-1: "SmartM2M; Smart Appliances Extension to SAREF; Part 1: Energy Domain".

[i.6] ETSI TS 103 410-2: "SmartM2M; Smart Appliances Extension to SAREF; Part 2: Environment Domain".

[i.7] ETSI TS 103 410-3: "SmartM2M; Smart Appliances Extension to SAREF; Part 3: Building Domain".

[i.8] AIOTI WG08 - Smart Cities: "Smart City Replication Guidelines. Part 1: Cross-Domain/Application Use Cases". Version 1.0. June 2018.

NOTE: Available at https://aioti.eu/aioti-wg08-report-on-smart-cities/.

[i.9] ETSI TS 103 410-4: "SmartM2M; Extension to SAREF; Part 4: Smart Cities Domain".

[i.10] oneM2M TS-0012 (V3.7.1): "Base Ontology".

[i.11]   OGC City Geography Markup Language (CityGML) Encoding Standard V2.0.

NOTE 1: CityGML is available at http://www.opengeospatial.org/standards/citygml.

NOTE 2: OGC CityGML open standardized data model for digital 3D models of cities and landscapes is available
         at https://www.citygml.org/about/.

[i.12]   AENOR UNE 178301:2015: "Smart Cities. Open Data".

NOTE: Available at https://www.aenor.com/normas-y-libros/buscador-de-normas/une?c=N0054318.

[i.13]   ISO 37120:2018: "Sustainable cities and communities -- Indicators for city services and quality of
             life".

NOTE: Available at https://www.iso.org/standard/68498.html.

[i.14]   ISO/IEC 30182:2017: "Smart city concept model -- Guidance for establishing a model for data
             interoperability".

NOTE: Available at https://www.iso.org/standard/53302.html.

[i.15]   ETSI GR CIM 002: "Context information Management (CIM); Use Cases (UC)".

NOTE: Draft and further publication status to be checked at
         https://portal.etsi.org/webapp/workProgram/Report_WorkItem.asp?wki_id=51347.

[i.16]   Draft GeoSPARQL standard proposed by Open Geospatial Consortium.

NOTE: Available at http://www.opengis.net/ont/geosparql.

[i.17]   ITU-T Recommendation Y.4903/L.1603 (10/2016): "Evaluation and assessment Key performance
             indicators for smart sustainable cities to assess the achievement of sustainable development goals".

NOTE: Available at http://handle.itu.int/11.1002/1000/12884.

3   Definitions and abbreviations

3.1   Definitions

For the purposes of the present document, the following terms and definitions apply:

ontology: formal specification of a conceptualization, used to explicit capture the semantics of a certain reality

3.2   Abbreviations

For the purposes of the present document, the following abbreviations apply:

AENOR	Asociación Española de Normalización (Spanish Association for Standardization)
AIOTI	Alliance for the Internet Of Things Innovation
CIM	Cross-cutting Context Information Management
CTN	Comité Técnico de Normalización
EU	European Union
FEMP	Federación Española de Municipios y Provincias (Spanish Federation of Municipalities and Provinces)
GPS	Global Positioning System
IEC	International Electrotechnical Commission
IoT	Internet of Things
ISA	Interoperability Solutions for European Public Administrations
ISG	Industry Specification Group
ISO	International Organization for Standardization
ITU-T	International Telecommunication Union - sector Telecommunication

KPI	Key Performance Indicator
MDR	Metadata Registry
OGC	Open Geospatial Consortium
PM	Particulate Matter
SAREF	Smart Appliances REFerence ontology
SAREF4CITY	SAREF extension for Smart Cities
SCCM	Smart City Concept Model
SKOS	Simple Knowledge Organization System
STF	ETSI Specialist Task Force
TNO	Netherlands Organization for Applied Scientific Research
TR	Technical Report
TS	Technical Specification
UC	Use Case
UNE	Una Norma Española (Spanish Standardization Association)
WG	Working Group
WGS84	World Geodetic System 1984

4   SAREF extension for the Smart City domain

SAREF [i.1] is a reference ontology for IoT created in close interaction with the industry during a study requested by the European Commission in 2015 [i.2] and subsequently transferred into ETSI TS 103 264 [i.3]. SAREF contains core concepts that are common to several IoT domains and, to be able to handle specific data elements for a certain domain, dedicated extensions of SAREF can be created. Each domain can have one or more extensions, depending on the complexity of the domain. As a reference ontology, SAREF serves as the means to connect the extensions in different domains. The earlier document ETSI TR 103 411 [i.4] specifies the rationale and methodology used to create, publish and maintain the SAREF extensions.

The present document specifies the requirements for an initial SAREF extension for the smart city domain based on a limited set of use cases and from available existing data models. The present document has been developed in the context of the STF 534 (https://portal.etsi.org/STF/STFs/STFHomePages/STF534.aspx), which was established with the goal to create SAREF extensions for the domains of Smart Cities, Smart Industry & Manufacturing, and Smart AgriFood. The STF 534 follows the outcomes of the earlier STF 513, which developed an updated SAREF specification [i.3] and the first extensions of SAREF in the energy [i.5], environment [i.6] and building [i.7] domains. The STF 534 consists of the following two main tasks:

1)   gather requirements, collect use cases and identify existing sources (e.g. standards, data models, ontologies, etc.) from the domains of interest (i.e. Smart Cities, Smart Industry & Manufacturing, and Smart AgriFood); and

2)   produce extensions of SAREF for each domain based on these requirements.

The present document focuses on the extension of SAREF for the smart cities domain, which will result in a new ontology, called SAREF4CITY, to be published in the companion ETSI TS 103 410-4 [i.9] as part of the SAREF extensions series ETSI TS 103 410 [i.5], [i.6] and [i.7].

5   Related initiatives

In this clause, some of the main related initiatives in terms of modelling and standardization in the smart cities domain are reviewed. Existing efforts range from national or international norms to rather specific models used in certain software solutions. Therefore, the potential stakeholders identified for this SAREF extension might be classified as: public administrations, associations related to the Internet of Things and Smart Cities, European projects, platforms for IoT data processing, and standardization bodies. For each type of stakeholder, the initiatives that have been taken into account are described next.

- **Standardization bodies:**

  - **oneM2M:** oneM2M is devoted to the development of technical specifications for M2M solutions related to the service layer which can be combined with existing hardware and software solutions. The main goal of the organization is to attract and involve organizations in domains such as telematics and intelligent transportation, healthcare, utilities, industrial automation, or smart homes, among others. oneM2M prepares, approves and maintains technical specifications and reports for use cases, service layer aspects, protocols, APIs, interoperability, data collection, and many other aspects of the M2M domain. The **oneM2M base ontology** [i.10] is the minimal ontology that enables achieving interoperability among organizations.

  - **OGC (Open Geospatial Consortium):** The OGC is an international organization devoted to the development of quality open standards for the global geospatial community. It includes different member types such as governments, commercial organizations, NGOs, or academic and research organizations. One of the standards developed by the OGC is **CityGML** [i.11], which consists of a model and SML-based format for the exchange and storage of virtual 3D models. In addition, OGC provides a standard model, **GeoSPARQL**, which supports the representation and querying of geospatial data based on semantic web technologies.

  - **AENOR CTN 178:** The Spanish Association for Standardization and Certification (AENOR, or UNE since 2017), is a private non-profit organization founded in 1986. AENOR published in 2015 the **UNE 178301:2015** [i.12]. The norm is intended to measure the maturity level of open data projects for smart cites, easing its development and deployment. The city-related domains considered in the norm are: business catalogue; cultural agenda; population; air quality; contracts, public procurement, and service providers; municipal budget and budget execution; public park loads; bus timetable, line, stops and fares; traffic; touristic places; and city street guide.

  - **ISO (International Organization for Standardization):** The ISO is a worldwide federation of national standardization bodies dedicated to develop international standards through technical committees specialized in a particular field. In 2014, ISO published the standard **ISO 37120:2018** [i.13], which establishes definitions and methodologies for indicators for city services and quality of life. This standard allows measuring the performance of any city, municipality or local government in a comparable and verifiable manner. In 2017, ISO in liaison with **IEC** (the International Electrotechnical Commission) published the standard **ISO/IEC 30182:2017** [i.14]. The Smart City Concept Model (SCCM) defines concepts and relationships that can be used to describe data from a smart city in order to facilitate interoperability.

- **Associations:**

  - **AIOTI:** The Alliance for Internet of Things Innovation, founded by the European Commission in 2015, consists of thirteen working groups; one of them is dedicated to Smart Cities, namely the WG08. This group focuses on IoT solutions to enhance city performance, safety and wellbeing, cost reduction and increase citizen engagement and active participation. The group has an interest in city-related sectors like transport, energy, healthcare, lighting, water, and waste, among others.

  - **FEMP (Federación Española de Municipios y Provincias):** The Spanish Federation of Municipalities and Provinces has recently published a guide for smart city open data publication that included the participation of around 40 representatives, from 8 different municipalities, as well as researchers and other bodies like organizations for open data, open participation and transparency in cities. In addition, the list of local entities supporting transparency and citizen participation includes 222 local entities from all the Spanish geography. The city-related domains for which the FEMP proposes datasets or vocabularies, and which extend the AENOR CTN 178 ones, are: municipal agenda; activities and events; public park loads; warnings, suggestions and complaints; public bikes; air quality; city street guide; census of premises, activities, terraces, restaurants and opening licenses; acoustic pollution; contracts, public procurement, and service providers; agreements; public debt; municipal equipment; traffic; sport equipment; touristic places; population; municipal budget and budget execution; public WiFi points and public transport.

- **IoT Platforms:**

  - **FIWARE:** FIWARE is software platform for smart cities to develop smart applications in multiple vertical sectors. FIWARE provides data models for the following domains: alarm; environment; civic issue tracking; device; indicator (KPI); parking; park and garden; point of interest; street lighting; transportation; waste management; and weather.

- **European projects and initiatives:**

  - **ISA²:** ISA² is a European programme for supporting the development of digital solutions that benefit from interoperable cross-border and cross-sector public services. This programme started the 1st of January 2016 and is planned to run until the 31st of December 2020. One of the solutions provided by this programme is a set of core vocabularies which are simplified, re-usable and extensible data models for capturing fundamental characteristics of entities. The core vocabularies developed by the time of writing this document are: Core Person, Registered Organization, Core Location, Core Public Service, Core Criterion and Core Evidence, Core Public Organization, and Core Public Event Vocabulary. Such vocabularies are published under the **Joinup** initiative that is part of the ISA² programme (https://joinup.ec.europa.eu/collection/semantic-interoperability-community-semic/core-vocabularies). The Joinup action is, more precisely, a European collaborative platform and catalogue where the core vocabularies are hosted.

  - **ESPRESSO:** The ESPRESSO H2020 project analysed different sectorial systems in order to develop a conceptual Smart City Information Framework based on open standards. The project analysed the core vocabularies for smart cities, which enable cities and stakeholders to share data in an interoperability way in different smart city sectors.

  - **VICINITY:** The VICINITY H2020 project will build and demonstrate a platform and ecosystem that provides "interoperability as a service" for infrastructures in the Internet of Things. The approach is bottom-up, decentralized, user-centric, and involving standardization without relying on a single standard. Different smart city domains are involved in the VICINITY pilots, such as buildings, energy, transport, and health.

6   Use cases

6.1   Use case 1: eHealth and Smart Parking

Caring of an aging population is one of the major challenges of the future of healthcare. An important step is the need to move from institutional care to assisted-living at home, in particular for elderly people living alone and for people with long-term needs and chronical illness (such as people with hypertension, dementia, or obesity). Electronic medical care services enable these people to obtain a better quality and independent life.

By making use of different IoT data coming from monitoring equipment, wearables and building sensors, the goal of the use case is, on the one hand, to provide assisted living to elderly people and people with long-term needs and, on the other hand, to support middle-aged municipal citizens to change their everyday way of living and habits to obtain a better quality and independent life. Actors in this use case include not only the monitored people and their close circle (relatives, neighbours), but also health service providers (ambulances, doctors, pathologists, dietitians), assistance services (call centres), and the same municipality.

For the case of assisted living to elderly people, the data would be collected from sensors from the building and smart home domains, for example motion sensors, occupancy sensors, or pressure mats, among others. The collected data would be used by added-value services to detect abnormal conditions in elderly people's daily life environment and to trigger alarms to the municipal 24-hour call centre where specialists can provide assistance. In addition, the use case is complemented with smart allocation of parking space when needed for municipality health services in case their actuation is needed in a particular location, for example when a user presses the panic button.

For the middle-aged people use case, the data would be collected from wearables (for example smart bands, pedometers, etc.) and IoT proximity sensors that track everyday activities. The role of the municipality in this case is to collect and process such data to create award and goal-oriented services based on individuals' needs that promote healthy life-styles among users. In addition, specialist knowledge provided by professionals like pathologists or dieticians could be incorporated in the use case by means of recommendations or by defining municipal-scale campaigns to promote fitness activities to citizens.

This use case has been adapted from the Pilea-Hortiatis (Greece) pilot scenario from the H2020 VICINITY project which deals with prevention, health promotion, mobilization and orientation in health facilities. The "Smart Parking and Assisted Living" use case defined in AIOTI WG08 [i.8] has also been taken into account in combination with the use case "Sharing information between parking management systems and traffic management applications" being defined in ETSI GR CIM 002 [i.15].

6.2   Use case 2: Air Quality Monitoring and Mobility

Air pollution is a well-known problem nowadays being especially critical in larger cities such as London, Rome or Barcelona, due to the presence of PM10 and PM25 particles. Consequently, reducing air pollution is becoming one of the main action points in local administrations in order to meet EU directives.

Even though cities have already deployed air quality sensors, the quantity of such sensors is usually limited. In addition, the location of such sensors might interfere in obtaining accurate air quality measurements; for example, when sensors are located in parks that are quite distant from road traffic. In this sense, a dense network of air quality sensors would increase the actual data from air quality allowing real-time route generation based on pollution levels. These new air pollution sensors could be integrated in the smartphones that users are already carrying and moving over the city, sending such data to a central monitoring and processing point. Taking this into account, one possible application is to divert traffic over less polluted routes, therefore reducing pollution level peaks by including such an option in GPS devices. Another possible application is avoiding high polluted roads for users exercising outside, for example running. This could be done by integrating the real-time pollution information within mobile running applications.

This use case has been adapted from the "Air Quality Monitoring, Traffic Routing and Road Pricing" use case defined in AIOTI WG08 [i.8] in combination with the use case "Traffic Management/Pricing based on Air Quality, Congestion, and other KPIs" being defined in ETSI GR CIM 002 [i.15]. The use case, together with road pricing depending on vehicle pollution levels is being investigated in on-going pilots in London and Barcelona.

6.3   Use case 3: Street Lighting, Air Quality Monitoring and Mobility

Street lighting is a key city infrastructure for citizens as it is directly associated to the sense of security at night by them. However, this idea of security in addition to the sense of wealth and modernity risen by lighting systems, is increasing the light pollution levels mostly in highly populated cities like Madrid. On the one hand, both the awareness about the light pollution consequences over citizens' health and the need for reducing costs in energy are pushing local administrations to find solutions for a more efficient street lighting system. On the other hand, city administrations should handle the well-known problem of air pollution suffered also by big cities due to the high concentration of vehicles emitting CO_2. Finally, there is also a need for reducing pedestrian accidents due to maintenance works and issues on the roads. Taking all this into account, city administrations should find a way to:

   a)   balance the energy spent on street lighting while keeping roads safe for pedestrians;

   b)   re-route traffic in order to reduce high concentrations of air pollution in specific points; and

   c)   provide alternative routes for pedestrians in order to avoid areas with air pollution and potential hazards due to road works or issues.

In this use case, local administrations need to provide and deploy the infrastructure to monitor traffic and manage the street lighting configuration. For example, there is a need for sensors to detect presence in order to reduce the intensity of lighting when there is no traffic or pedestrians and increase it otherwise. Citizens could register road incidences by means of mobile or web applications as well as city reporting services. Such information could be used for suggesting safer routes to pedestrians. Final users could be both drivers, who could be re-directed to different routes according to the air pollution concentration in specific points, or pedestrians and cyclers who could be re-directed according to the safety and pollution conditions of the roads.

This use case has been adapted from the "Smart Street Lighting, Air quality Monitoring and Pedestrian Safety" use case defined in AIOTI WG08 [i.8] in combination with the use case "Smart Street Lighting" being defined in ETSI GR CIM 002 [i.15]. More precisely, a pilot for street lighting and pedestrian safety is being developed by the CeDInt Living Lab Illumination project https://www.cedint.upm.es/en/project/living-lab-illumination.

7   Requirements

This clause presents the ontological requirements resulting from a reverse engineering process that was carried out taking as input several smart city-related initiatives from those listed in clause 5. More precisely, the selected inputs were data models, ontologies, datasets and standards provided by OGC, FEMP, ISO, FIWARE and AENOR; the specific input resources will be drilled down below, for each of the categories taken into account. The categories considered are: Administrative area, City object, Event, KPI, Public Service and Topology.

It should be mentioned that these categories have been validated during the "SAREF4CITY Validation Workshop" at the IoT Week in Bilbao on the 4th of June of 2018. During the workshop, attendees validated the use cases proposed above and the list of requirements for the above-mentioned categories. According to the feedback and outcomes of the workshop, the following actions were carried out:

- Some requirements that were scored as "no relevant" by participants were discarded.

- Some requirements were identified as duplicated and only one requirement was kept.

- Requirements referring to regional particularities were discarded, for example the modelling of "province" information.

- The description of some requirements was simplified or clarified.

- New requirements were identified.

During the ontological requirements reengineering process and the validation workshop it was observed that there are different layers of requirements, as shown in Figure 1. In such figure the core SAREF model for devices and measurements is represented in the centre of the picture and the categories grouping the requirements are placed around such core. As it can be observed, there are general categories (depicted in dark blue), namely Administrative area, City object, Event, KPI, Public Service and Topology. This subset of categories is considered core and general enough in the smart city domain in order to be implemented in the SAREF4CITY extension. The requirements for these categories are detailed in the remaining of this clause.

A set of requirements for the domain-specific categories (depicted in light blue), namely Commercial Premises, Organization, Parking, Tourism, Transport, Address, and Traffic, have been also identified during the ontological requirements reengineering process. However, as they are too domain-specific and the SAREF4CITY extension does not intend to model any particular domain in detail, these requirements are listed in the next clause 8 and are proposed to be taken into account in future SAREF extensions.
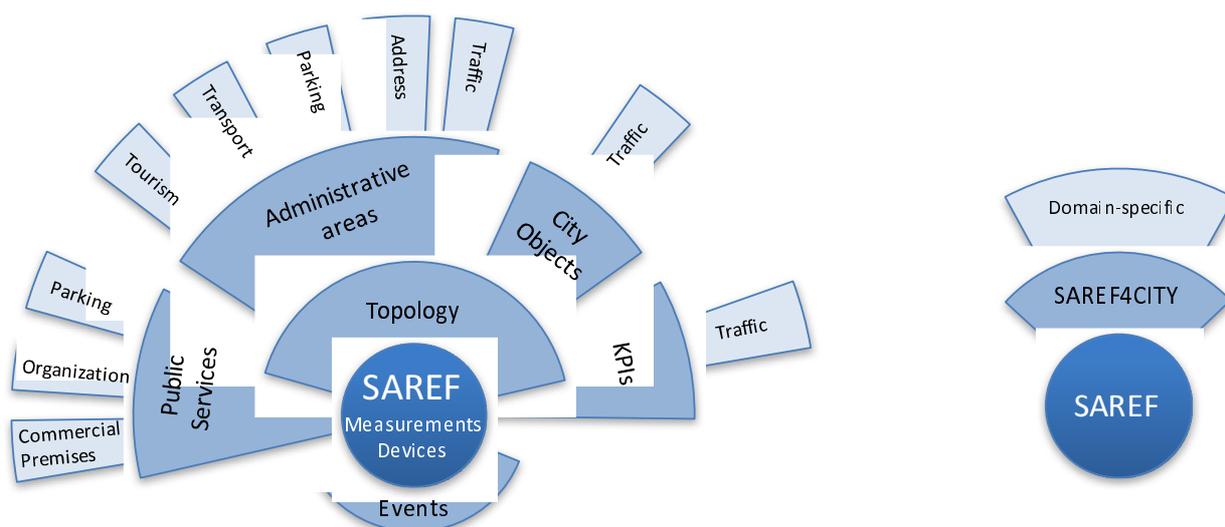
Figure 1: SAREF4CITY categories

Table 1 presents the requirements for the "Administrative area" category. These requirements have been reengineered from:

- Territory and street map vocabularies referenced by AENOR norm UNE 178301:2015 [i.12] http://vocab.linkeddata.es/datosabiertos/def/sector-publico/territorio and http://vocab.linkeddata.es/datosabiertos/def/urbanismo-infraestructuras/callejero

- GeoSPARQL standard proposed by OGC [i.16]

- Types of administrative territorial units within the Member States of the European Union published by the Metadata Registry (MDR) http://publications.europa.eu/mdr/authority/atu-type/index.html

Table 1: Requirements for the "Administrative area" category

Id	Requirement
CITY-1	A city is a large human settlement. A city is distinguished from other human settlements by its relatively great size, but also by its functions and its special symbolic status, which may be conferred by a central authority.
CITY-2	A city can contain neighbourhoods or districts.
CITY-3	A neighbourhood (British English), or neighborhood (American English; see spelling differences), is a geographically localized community within a larger city, town, suburb or rural area.
CITY-4	A district is a type of administrative division that, in some countries, is managed by local government. Across the world, areas known as "districts" vary greatly in size, spanning regions or counties, several municipalities, subdivisions of municipalities, school district, or political district.
CITY-5	A district can belong to a city.
CITY-6	An administrative division, unit, entity, area or region, also referred to as a subnational entity, constituent unit, or country subdivision, is a portion of a country or other region delineated for the purpose of administration.
CITY-7	A neighbourhood, district, city, etc. can contain a road.
CITY-8	A city can be defined by a geometry.
CITY-9	A district can be defined by a geometry.
CITY-10	A country can be defined by a geometry.
CITY-11	An administrative area can be defined by a geometry.
CITY-12	A spatial thing can be an administrative area, which can be cities, districts or countries.
CITY-13	A city can include different administrative areas.
CITY-14	A spatial thing can belong to one or more administrative areas or other delimited areas like neighbourhoods.

Table 2 presents the requirements for the "City Object" category. These requirements have been reengineered from:

- GeoSPARQL standard proposed by OGC [i.16]

- WGS84 Geo Positioning vocabulary https://www.w3.org/2003/01/geo/wgs84_pos

- OGC CityGML open standardized data model for digital 3D models of cities and landscapes [i.11]

- FEMP Open Data guide exemplary datasets:

    - http://datos.alcobendas.org/dataset?q=equipamiento&sort=score+desc%2C+metadata_modified+desc

Table 2: Requirements for the "City Object" category

Id	Requirement
CITY-15	A city object can be defined by a geometry.
CITY-16	A city object can be located in a given point.
CITY-17	A city can have city objects.
CITY-18	Each city object can have a location.
CITY-19	Some specific types of city objects can be: automated external defibrillator, urban furniture (bench, basket, street lights, etc.), cameras, or monuments.
CITY-20	A spatial thing can be a city object.

Table 3 presents the requirements for the "Event" category. These requirements have been reengineered from:

- Schema.org cross-domain vocabulary http://schema.org/

- Cultural agenda vocabulary referenced by AENOR norm UNE 178301:2015 [i.12] http://vocab.linkeddata.es/datosabiertos/def/cultura-ocio/agenda

Table 3: Requirements for the "Event" category

Id	Requirement
CITY-21	An event is something that occurs in a certain place during a particular interval of time.
CITY-22	An event can have a starting date.
CITY-23	An event can have an ending date.
CITY-24	An event can have a starting hour.
CITY-25	An event can have an ending hour.
CITY-26	An event can take places in a given location.
CITY-27	An event can have a given accessibility type.
CITY-28	An event can be organized by one or more agents.
CITY-29	There can be different types of events.
CITY-30	An event can contain sub-events.
CITY-31	There can be recurrent events.

Table 4 presents the requirements for the "KPI" category. These requirements have been reengineered from:

- FIWARE data model for KPIs http://fiware-datamodels.readthedocs.io/en/latest/KeyPerformanceIndicator/doc/spec/index.html

- ITU-T Recommendation Y.4903/L.1603 (10/2016) [i.17]

- ISO/IEC 30182:2017 [i.14]

Table 4: Requirements for the "KPI" category

Id	Requirement
CITY-32	A 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.
CITY-33	A KPI has a name.
CITY-34	A KPI can assess an organization, service, process or product.
CITY-35	A KPI has a description.
CITY-36	A KPI can be calculated by an organization.
CITY-37	A KPI can aggregate different entities or attributes (aggregated data).
CITY-38	A KPI can have a calculation period over which it is measured.
CITY-39	A KPI can take a given value in a given timestamp.
CITY-40	A KPI can have a creation date.
CITY-41	A KPI can have an expiration date.
CITY-42	A KPI can have a last update date.
CITY-43	A KPI might refer to a given location of an area.
CITY-44	A KPI might refer to a given address of an area.
CITY-45	A KPI might refer to an area denoted by a textual geographical information such as district, borough or other specification of the KPI coverage.
CITY-46	A KPI can have an indicator unit.
CITY-47	A KPI can be a measure of demography, characteristics, activity or performance.

Table 5 presents the requirements for the "Public service" category. These requirements have been reengineered from:

- Core Public Service Vocabulary v1.0.1 proposed by the joinup European initiative
  https://joinup.ec.europa.eu/release/core-public-service-vocabulary/101

- FEMP Open Data guide exemplary datasets:

  - http://opendata-ajuntament.barcelona.cat/data/es/dataset?q=equipamiento

  - http://datosabiertos.malaga.eu/dataset?tags=equipamiento

  - https://www.zaragoza.es/sede/portal/datos-abiertos/servicio/catalogo/300

    http://gobiernoabierto.valencia.es/es/dataset/?id=equipamientos-municipales

Table 5: Requirements for the "Public service" category

Id	Requirement
CITY-48	Public service is a service which is provided by government either directly (through the public sector) or by financing provision of services.
CITY-49	A public service can have a name.
CITY-50	A public service can have a description.
CITY-51	A public service can be available in different languages.
CITY-52	A public service can be regulated by a set of rules.
CITY-53	A public service can be related to another.
CITY-54	A public administration can provide a public service.
CITY-55	An organization can deliver a public service.
CITY-56	A person, organization or group can use a public service.
CITY-57	A public service can be available within an area.
CITY-58	Different types of facilities can be: sport facilities, educational facilities (nursery schools, schools, colleges, universities, etc.), cultural facilities (museum, theatre, libraries, etc.), elderly people facilities, health-related facilities, leisure time facilities, restaurants, cemeteries, markets, malls, environment-related facilities, information points, animal and plant-related facilities, social service facilities, wi-fi points, parks, police offices, co-working centres, business incubators, accommodation, or mail offices.

Table 6 presents the requirements for the "Topology" category. These requirements have been reengineered from:

- GeoSPARQL standard proposed by OGC [i.16]

Table 6: Requirements for the "Topology" category

Id	Requirement
CITY-59	Spatial things are defined by a geometry.
CITY-60	A spatial thing can contain other spatial things.
CITY-61	A spatial thing can be located at a given point.

# 8		Additional Requirements

This clause provides the set of identified requirements for specific subdomains that might appear in Smart City use cases. It should be reminded that these are additional requirements that are not considered core for the SAREF4CITY ontology and, therefore, are not planned to be implemented in such extension. Instead, they are proposed for further specializations of the SAREF ontology and are included here in order to ensure that SAREF4CITY supports them.

Table 7 presents the requirements for the "Address" category. These requirements have been reengineered from:

- ISA Programme Location Core Vocabulary https://www.w3.org/ns/locn

- Types of administrative territorial units within the Member States of the European Union published by the Metadata Registry (MDR) http://publications.europa.eu/mdr/authority/atu-type/index.html

- SKOS version of the "Administrative territorial unit Named Authority List" within the Member States of the European Union published by the Metadata Registry (MDR) http://publications.europa.eu/mdr/resource/authority/atu/skos/atu-skos.rdf

- Postal address and street map vocabularies referenced by AENOR norm UNE 178301:2015 [i.12] http://vocab.linkeddata.es/datosabiertos/def/urbanismo-infraestructuras/direccion-postal and http://vocab.linkeddata.es/datosabiertos/def/urbanismo-infraestructuras/callejero

Table 7: Requirements for the "Address" category

Id	Requirement
D1	An address is a collection of information, presented in a mostly fixed format, used to give the location of a building, apartment, or other structure or a plot of land, generally using political boundaries and street names as references, along with other identifiers such as house or apartment numbers.
D2	An address can have a post code.
D3	A resource can have an address.
D4	An address can have a full address.
D5	An address can have a post office box number.
D6	An address can have a thoroughfare.
D7	An address can have a locator designator.
D8	An address can be located in a place, or building, property or complex.
D9	An address can be located in a geographic area or locality that is its area.
D10	An address can have a postal division, usually the city.
D11	An address can be located in a region, county, state or other area that encompasses several localities. (admin unit level 2).
D12	An address can be located in a country (admin unit level 1).
D13	An address can have a post code (postal code, zip code).
D14	An address can have a unique identifier.
D15	An address, section, etc. can belong to a road.

Table 8 presents the requirements for the "Commercial premises" category. These requirements have been reengineered from:

- GeoSPARQL standard proposed by OGC [i.16]

- Commercial premises vocabulary referenced by AENOR norm UNE 178301:2015 [i.12] http://vocab.linkeddata.es/datosabiertos/def/comercio/tejido-comercial

Table 8: Requirements for the "Commercial premises" category

Id	Requirement
D16	Commercial premises are premises in which commercial activities can take place.
D17	A spatial thing can be a commercial premise or a commercial area.
D18	Commercial areas are areas with a significant quantity of commercial premises.
D19	There are different types of commercial premises.
D20	Commercial premises can be defined by a geometry.
D21	Commercial premises can belong to a neighbourhood, district, or city.
D22	Commercial areas can be defined by a geometry.
D23	A commercial area can belong to a neighbourhood, district, city.
D24	Commercial premises have a given accessibility type.

Table 9 presents the requirements for the "Organization" category. These requirements have been reengineered from:

- Registered Organization Vocabulary https://www.w3.org/TR/vocab-regorg/

- Core Public Organization Vocabulary v1.0.0 proposed by the joinup European initiative https://joinup.ec.europa.eu/release/core-public-organisation-vocabulary-v100

Table 9: Requirements for the "Organization" category

Id	Requirement
D25	A public organization is a type of organization.
D26	An organization can have a name.
D27	An organization can have a contact point.
D28	An organization can have an address.
D29	An organization can have suborganizations or departments.
D30	An organization can have a description.
D31	A public organization can have an associated function/responsibility.
D32	A registered organization can represent an organization that gains legal entity status by the act of registration.
D33	A registered organization can have a legal name.
D34	A registered organization can have more than one alternative names.
D35	There are different types of organizations.
D36	A registered organization can have a status.
D37	A registered organization can have activities associated.
D38	A registered organization can have a legal status.
D39	An agent can be associated to a registered organization that in some way acts as a registered legal entity for it.

Table 10 presents the requirements for the "Parking" category. These requirements have been reengineered from:

- GeoSPARQL standard proposed by OGC [i.16]

- Equipment vocabulary referenced by AENOR norm UNE 178301:2015 [i.12] http://vocab.linkeddata.es/datosabiertos/def/urbanismo-infraestructuras/equipamiento/

Table 10: Requirements for the "Parking" category

Id	Requirement
D40	Parking facilities are spaces designated for stopping and disengaging a vehicle and leaving it unoccupied.
D41	The parking facilities can have a given number of places.
D42	A park facility can be defined by a geometry.
D43	A park facility can belong to a neighbourhood, district, city.
D44	A spatial thing can be a park facility.

Table 11 presents the requirements for the "Tourism" category. These requirements have been reengineered from:

- GeoSPARQL standard proposed by OGC [i.16]

- WGS84 Geo Positioning vocabulary https://www.w3.org/2003/01/geo/wgs84_pos

- Tourism vocabulary referenced by AENOR norm UNE 178301:2015 [i.12]
  http://vocab.linkeddata.es/datosabiertos/def/turismo/lugar

Table 11: Requirements for the "Tourism" category

Id	Requirement
D45	An itinerary is a schedule or route of destinations or activities.
D46	A tourist attraction is a place of interest where tourists visit, typically for its inherent or exhibited natural or cultural value, historical significance, natural or built beauty, offering leisure and amusement.
D47	An itinerary can contain touristic places.
D48	A touristic area is a place where one or more tourist attractions are located.
D49	A touristic area can contain touristic places.
D50	A monument is a type of - usually three-dimensional - structure that was explicitly created to commemorate a person or event, or which has become relevant to a social group as a part of their remembrance of historic times or cultural heritage, due to its artistic, historical, political, technical or architectural importance.
D51	Urban art works are artistic pieces of work that are exposed or are part of a city and its structures.
D52	There are historical buildings.
D53	A historical building can be defined by a geometry.
D54	A historical building can be located at a given point.
D55	A historical building can belong to a neighbourhood, district, city.
D56	A touristic attraction can be defined by a geometry.
D57	A touristic attraction can be located at a given point.
D58	A touristic area can be defined by a geometry.
D59	A touristic area can belong to a city, province, etc.
D60	A monument can be located in a given point.
D61	An urban art work can be located in a given point.
D62	A spatial thing can be a building, historical building, a touristic place, a touristic area, a monument or an urban art work.

Table 12 presents the requirements for the "Traffic" category. These requirements have been reengineered from:

- Traffic and street map vocabularies referenced by AENOR norm UNE 178301:2015 [i.12]
  http://vocab.linkeddata.es/datosabiertos/def/transporte/trafico and
  http://vocab.linkeddata.es/datosabiertos/def/urbanismo-infraestructuras/callejero

- GeoSPARQL standard proposed by OGC [i.16]

- WGS84 Geo Positioning vocabulary https://www.w3.org/2003/01/geo/wgs84_pos

- FEMP Open Data Guide exemplary datasets:

  - https://www.donostia.eus/datosabiertos/catalogo/camaras-trafico

  - http://datosabiertos.malaga.eu/dataset?tags=tr%C3%A1fico

  - http://datos.madrid.es/sites/v/index.jsp?vgnextoid=02f2c23866b93410VgnVCM1000000b205a0aRCRD&vgnextchannel=374512b9ace9f310VgnVCM100000171f5a0aRCRD

  - http://datosabiertos.malaga.eu/dataset?tags=tr%C3%A1fico

Table 12: Requirements for the "Traffic" category

Id	Requirement
D63	A road can be composed by sections.
D64	Traffic measurements quantify traffic characteristics.
D65	The traffic can be measured by its intensity.
D66	The traffic measurement can be about a section of a road.
D67	A city can have tunnels, reserved lanes, and residential priority areas.
D68	Parking facilities can exist for bikes and vehicles.
D69	A city can have a bike lane.
D70	A city can have traffic cameras.
D71	The traffic intensity can include information as number of vehicles circulating, mean speed of vehicles in tunnels, traffic jams and slow-moving traffic.
D72	There can be traffic interruptions.
D73	A road can be defined by a geometry.
D74	Parking facilities can be located in a given point.
D75	A traffic camera can be located in a given point.
D76	The traffic intensity can be measured in a given location at certain point in time.
D77	A spatial thing can be a road.
D78	Spatial things can be cars, bikes, parking lots, etc.

Table 13 presents the requirements for the "Transport" category. These requirements have been reengineered from:

- Public transport vocabulary referenced by AENOR norm UNE 178301:2015 [i.12] http://vocab.linkeddata.es/datosabiertos/def/transporte/transporte-publico

- WGS84 Geo Positioning vocabulary https://www.w3.org/2003/01/geo/wgs84_pos

Table 13: Requirements for the "Transport" category

Id	Requirement
D79	A stop area is a location where one or more transport lines have a stop point.
D80	A stop point is a location in which users of a public transport service can get in or out of the service.
D81	A line can have stops in certain stop points.
D82	There are different means of transport.
D83	A stop point can be located in a given point.
D84	A transport line or route represents a sequence of stop points and is generally known to the public by a similar name or number.
D85	A spatial thing can be a stop point.
D86	Stop areas can contain stop points.

9   Conclusions

The present document describes the use cases taken into account for the development of the SAREF4CITY extension as well as the 61 final requirements defined to be implemented in such extension. These requirements are split into the following categories: Administrative Area (14), City Object (6), Events (11), KPI (16), Public Service (11), and Topology (3). In addition, 86 additional domain-specific requirements are presented that, although aimed to be taken into account in future SAREF extensions, are included in the present document to ensure that also the initial SAREF4CITY extension supports them.

Finally, during the "SAREF4CITY Validation Workshop" held at the IoT Week in Bilbao on the 4th of June of 2018, other conclusions regarding the scope of SAREF family of ontologies arose. One of them was the need for developing specific extensions for domains such as health, transport, etc. For example, the health domain involves also the need of representing roles for agents, daily activities that patients or people being monitored carry out, lifestyle, habits, patient level of autonomy, emotional status, conditions, etc.

Annex A:
Bibliography

- ETSI TS 103 267: "SmartM2M; Smart Appliances; Communication Framework".

- oneM2M TS-0001: "Functional Architecture".

- oneM2M TS-0002: "Requirements".

History

Document history		
V1.1.1	September 2018	Publication