MIMs Plus: Living-in.EU Technical Specifications

1. Background

This document contains the technical specifications of the Living-in.EU (LI.EU) upscaling declaration[1] initiative MIMs Plus,[2] which is based on existing Minimal Interoperability Mechanisms (MIMs) plus additional fundamental building blocks, hence the name. It is one of three deliverables from the LI.EU Technical sub group, the others being a *concept paper,*[3] describing the scope and time plan for the work, and *operational guidance*, with practical guidance on how the technical specifications can be used.

Overall, the LI.EU declaration has six guiding principles, of which number five and six are especially relevant from a technical perspective:

1. A citizen-centric approach;
2. A city-led approach at EU level;
3. The city as a citizen-driven and open innovation ecosystem;
4. Ethical and socially responsible access, use, sharing and management of data;
5. Technologies as key enablers; and,
6. Interoperable digital platforms based on open standards and technical specifications, Application Programming Interfaces (APIs) and shared data models.

In addition to the principles above, there are five commitments made by the LI.EU signatories[4] and supporting parties[5], each with a sub group where the work is coordinated: Legal, Financing, Skills, Monitoring & Measuring, and Technical. The technical commitment sub group has the following aims:

1. Use common standards and technical specifications;
2. Make key enablers (including data, infrastructure and services) available to all; and,
3. Establish a common market.

The first aim is covered by this MIMs Plus specification document, whereas the second and third aims are of a more operational nature, which will be addressed in the operational guidance, to be developed in collaboration with the other LI.EU sub groups.

[1] https://www.living-in.eu/declaration
[2] Latest version available at https://www.living-in.eu/mimsplus
[3] https://www.living-in.eu/tech/concept-paper
[4] https://www.living-in.eu/we-signed
[5] https://www.living-in.eu/we-support

The baseline for the MIMs Plus was the original "input paper" referenced in the LI.EU Declaration, which refers to a consensus between a global group of cities, towns, and rural areas, and a variety of European initiatives to achieve minimal interoperability of solutions, services, and data at programme, project, and city level, under the moniker "MIMs Plus". MIMs Plus ensures scalability, shareability, and sustainability of outcomes, and protects governments, the public, and other stakeholder groups against vendor lock-in and undue influence.

MIMs Plus document consists of two parts:

(1) an introduction and background (Section 1)
(2) the actual specifications (Sections 2–5).

The structure of the specifications follows the framework of the OASC Minimal Interoperability Mechanisms (MIMs), and then adds relevant European specifications and initiatives (Plus).

1. **MIMs (mims.oascities.org)** are the minimal but sufficient capabilities needed to share, use and re-use data across systems, and they address the following three key layers and the cross-cutting data models and architectural framework, each with a set of MIMs inside:
    - **Interaction**: knowledge and context information exchange, rules of access and use for data and services, and management of location data;
    - **Integrity**: protection of rights (personal data, privacy, dignity, equality, …); transparency in automated decision making (societal governance of all technology use and deployment), and security (systems and society);
    - **Impact:** driven by societal objectives with measurable outcomes towards those objectives, taking into account existing indicators, analytics, and resource management frameworks.
2. **European specifications and initiatives** under the 'Plus' banner refer to EIF4SCC, ISA^2, CEF, INSPIRE, EIP-SCC, ELISA, LORDI, DIGISER, among others. Minimal interoperability requires further integration based on local priorities and legacy, so governments and other stakeholders can add their preferred technical stacks, tools and management standards into operations and development, with an open-ended baseline that can evolve as needs arise.

This document is based on and complements the input paper of the LI.EU Declaration, states the current state of the art and gives recommendations for technical specifications. It aims to build capacity on top of standards, mechanisms, services, guidelines, and tools that enable interoperability of data platforms for cities and communities, to mainstream the delivery of services with a strong positive local impact, while at the same time addressing overall European goals.

What are MIMs?
Minimal Interoperability Mechanisms (MIMs) are the minimal but sufficient capabilities needed to achieve interoperability of data, systems, and services between buyers, suppliers and regulators across governance levels around the world. Because the mechanisms are based on an inclusive list of baselines and references, they take into

account the different backgrounds of cities and communities and allow cities to achieve interoperability based on a minimal common ground.

Implementation can be different, as long as crucial interoperability points in any given technical architecture use the same interoperability mechanisms. MIMs are vendor neutral and technology agnostic, meaning that anybody can use them and integrate them into existing systems and offerings, complementing existing standards and technologies.

Reading Guide

The body of this document is organised into four sections:

- introduction to Architectural Framework and Shared Data Models
- Interaction layer
- Integrity layer
- Impact layer

Each section (and the individual MIMs that are part of the abovementioned interoperability layers) delves further into

- Goals: Identifies what the MIM aims to achieve and what its main purpose is;
- Capabilities: Focuses on how the MIMs will enable those goals to be achieved and what are the necessary requirements;
- Recommended specifications: Specs and standards proven to attain the goals;
- Means of verification: How conformance is tested and by whom it can be certified.

Governance

The governance of this specification document as outlined in the LI.EU concept paper is quite straightforward: The MIMs Plus technical specifications are developed by the LI.EU Tech sub group through regular meetings, convened by the sub group lead, OASC. All signatories of the LI.EU declaration and LI.EU partners can contribute to the document. When a stable version is reached, it is put forward for approval to the LI.EU Steering Board, convened by the European Commission. Each of the specific elements such as SAREF, OASC MIMs, INSPIRE, EIRA, OneM2M, etc., are governed by their respective governance fora.

Version history

Version	**Date**	**Main changes**
1.0	20 October 2019	Initial draft consolidated report on technical specifications for the Digital Europe Programme and Living-in.EU (LI.EU)
2.0	6 December 2019	Major update in advance of the pre-launch of LI.EU in Oulu, Finland, 10 December
2.1	9 March 2020	Update with input from European Commission

		services – DIGIT, GROW perspectives
2.2	29 April 2020	Update before first meeting in the LI.EU Tech sub group (12 May) – further fine-tuning of perspectives from the group
2.3	23 June 2020	Update before third meeting in the LI.EU Tech sub group (24 June) – focus on Personal Data Management and Fair AI, plus adjustments from the group
2.4	24 July 2020	Adjustments of Personal Data Management and Fair AI
2.5	25 September 2020	Update on the Personal data and Fair AI
3.0	18 December 2020	Version release of Personal data and Fair AI
4.0 DRAFT	23 June 2021	Update prior to the LI.EU Tech sub group session on 28 June, incorporating input from OASC Sweden, the Swedish signatories to the LI.EU Declaration and OASC following the OASC MIMs v1.0.1 update adopted by the OASC Council of Cities meeting on 16 June
4.0 FINAL DRAFT	23 July 2021	Incorporated updated contribution from JRC regarding MIM7: Geospatial Information Management and MIM: 2Data Models. Added MIM4 draft specification from Helsinki.

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2. Architecture Framework & Shared Data Models

2.1. Architecture Framework

Goals

The goals of an architecture framework model for a digital ecosystem for cities and communities is to ensure that the capabilities of interoperable data platforms consider both functional and non-functional requirements needed to implement the minimal interoperability that cities and communities need to deliver a prosperous, sustainable, and inclusive future for their citizens.

The fundamental perspective is that of the technical capabilities required for minimal data interoperability. This focus backgrounds many implementation aspects, e.g., related to specific software and hardware stacks, and it allows great flexibility when it comes to adapting concrete deployment and integration to a local context. It is also based on a realisation from current experiences that establishing data spaces on a minimal but sufficient common ground can be a catalyst to delivering mainstream trusted services for cities and communities in a connected world.

The requirements for interoperable city data platforms should lead to specifications that ensure that the platforms are reliable, durable, future-proof and efficient so that the city can build on the platforms and foster further innovations and evolution. These specifications should also ensure that the platforms can:

- extend to a ‘system of systems’ with all relevant digital means of a community,
- scale to the needs of the cities and communities; and,
- guarantee privacy and security by design, making the platforms trustworthy.

Open-source development and the involvement of communities are powerful methods in order to guarantee transparency and consequently, trust in the platforms for public operators. This particular aspect will be particularly relevant when injecting algorithms based on AI mechanisms into the platforms.

The implementation of minimal interoperability provides the common technical ground that cities and communities need to enable choice, flexibility, value for money and independence, through avoiding vendor lock-in. The platforms should support formal, de-facto and emerging standards, in order to ensure they are future-proof and stable.

The trustworthiness and the interoperability of the platforms address the triple baseline of social, environmental, and economic benefits, and supports strategic aims such as the United Nations Sustainable Development Goals (SDGs).

The platform architectures proposed in the recommended specifications and frameworks have been validated in large scale pilots by a wide variety of companies in close and direct partnerships with the cities and communities, as well as networks of cities.

The LI.EU Tech sub group has recognised the Minimal Interoperability Mechanisms adopted by the OASC Council of Cities[6] as a relevant approach to organise the architecture framework and to strike a balance of precision in the technical specifications, neither over- nor under-specifying. The current document covers MIMs 1-10 in line with the new MIMs adopted during the OASC Council of Cities meeting on 16 June 2021. Complementary sources of potential interoperability requirements include the European Interoperability Framework[7] and the European Interoperability Reference Architecture[8].

OASC MIMs (updated June 2021)

MIM	Subject	Name	Status
MIM1	Context	OASC MIM1: Context Information Management	Governance
MIM2	Data Models	OASC MIM2: Shared Data Models	Governance
MIM3	Contracts	OASC MIM3: Ecosystem Transactions Management	Capability
MIM4	Trust	OASC MIM4:Personal Data Management	Capability
MIM5	Transparency	OASC MIM5: Fair Artificial Intelligence	Capability
MIM6	Security	OASC MIM6: Security management	Work item
MIM7	Places	OASC MIM7: Geospatial information management	Work item
MIM8	Indicators	OASC MIM8: Ecosystem indicator management	Work item

[6] https://oascities.org/wp-content/uploads/2019/06/OASC-MIMs.pdf
[7] https://ec.europa.eu/isa2/sites/isa/files/eif_brochure_final.pdf
[8] https://joinup.ec.europa.eu/sites/default/files/distribution/access_url/2019-03/76cb237b-0de8-464c-84ca-1327945eac3e/EIRA_v3_0_0_Overview.pdf

MIM9	Analytics	OASC MIM9: Data Analytics Management	Work item
MIM10	Resources	OASC MIM10: Resource Impact Assessment	Work item

Architectural Capabilities

The framework shown in Figure 1 (below) provides a description and guidelines of a common architecture/framework, including a layered overview positioning of all the components and interfaces, as well as the associated requirements and specifications. They include a description of reference implementations, including conformance testing and/or feedback from market use validation.

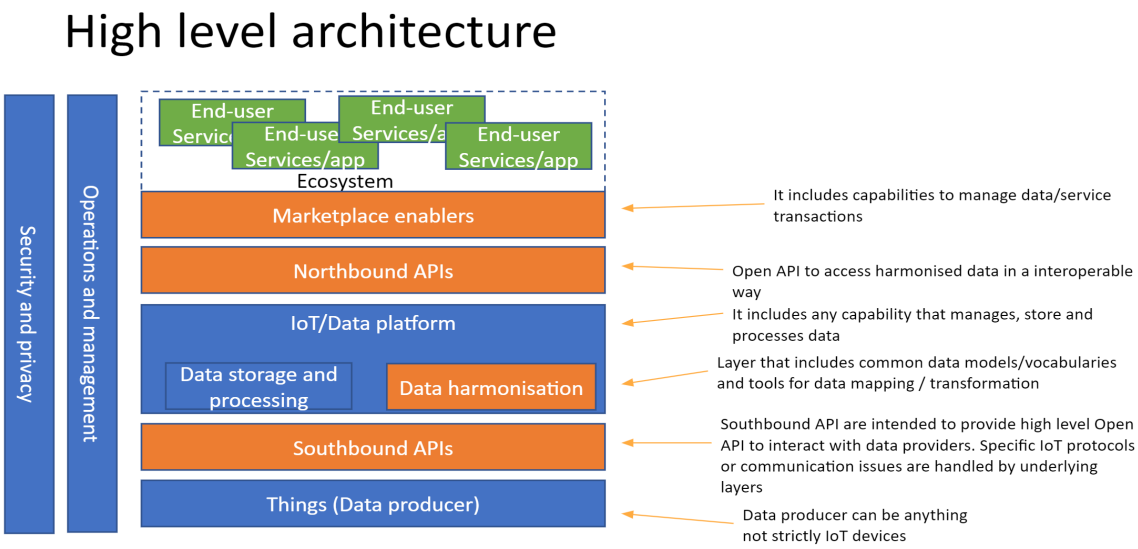

Figure 1. High-level architecture framework model.

In particular, we consider the following topics as common architectural design principles:

- A layered and capability-based approach to follow a common architectural model in different cities/domains
- Based on open international standards (where available): we do not want to reinvent the wheel, and this will also ensure stable and widely-used technological approaches
- Compliant with existing technical solutions (e.g., already present in the cities with many legacy systems) focusing on interoperable interfaces rather than component implementation
- Modular and scalable solutions for small and big cities to support different deployment scenarios and performance requirements
- Security and privacy by design
- Availability of reference implementations to foster and simplify the adoption in cities
- Architecture modularity that provides the possibility to implement any component with different/proprietary technologies

- Based on global, standard-based open APIs to enable both southbound/northbound interoperability
- Data harmonisation and global standards-based semantic interoperability through the adoption of common, linked data models

A more detailed and robust ontology will be included in a future version of this document.

In this document the following parts are further discussed:

- Data models and Context information management: Context information management realises the Northbound open APIs and the Southbound APIs as a high-level open API. Data models provide the harmonised models.
- Marketplace: discusses the different marketplace APIs and transaction management (commercial as well as non-commercial).
- Data harmonisation: ensures that data models can be harmonised with shared data models and between different standards.

Recommended specifications and frameworks

- EIP SCC Reference architecture on Open Urban Platform (DIN SPEC 91357:2017-12) - Reference Architecture Model Open Urban Platform (OUP) https://www.beuth.de/en/technical-rule/din-spec-91357/281077528
- Guidelines for SynchroniCity Architecture https://synchronicity-iot.eu/wp-content/uploads/2018/05/synchronicity_d1_3_guidelines_for_synchronicity_architecture.pdf
- Synchronicity Reference Architecture for IoT Enabled Smart Cities, Update https://synchronicity-iot.eu/wp-content/uploads/2018/09/SynchroniCity_D2.10.pdf
- oneM2M Release 2 and Release 3 set of specifications. oneM2M Release 2 has been formally approved as ITU-T recommendation under Y.4500 series. oneM2M is a partnership project, where EU is represented by ETSI, that specifies a common service layer for IoT. OneM2M is applicable to many verticals including smart cities. oneM2M specifications cover requirements, architecture, APIs, security, interworking and data models. Although not chartered to produce open source, there are several open source implementations supporting oneM2M, those include Eclipse OM2M and South Korea OCEAN.
- The EIRA Library of Interoperability Specifications, ELIS is a repository of technical specifications based in open standards for the EIRA ABBs
- The CAMSS assessment Library is a repository of ICT open standards assessed using CAMSS
- SALAR Ten Proposed Principles for IoT-systems – best practices for purchasing/achieving IoT-systems or IoT capabilities (Swedish): https://inera.atlassian.net/wiki/spaces/AR/overview

Means of verification

To guarantee the reliability and security of these platforms, certification tests by independent bodies may be applied to them in order to provide the necessary guarantees to public operators. Concrete tests are still being considered.

References

- ITU-T (06/2012) Series Y: Overview of the Internet of Things - Global information infrastructure, internet protocol aspects and next-generation networks-frameworks and functional architecture models
- ISO/IEC JTC1 Study Group on Smart Cities, “Resolutions 3, ISO/IEC JTC 1 N 11894, 201311-12,” 2012
- Systemic Standardisation Approach to Empower Smart Cities and Communities: “ESPRESSO Project”
- “The European Innovation Partnership on Smart Cities and Communities EIP-SCC,” [Online]. Available: https://smart-cities-marketplace.ec.europa.eu/
- ETSI GS CIM 009 V1.1.1 (2019-01) - Context Information Management (CIM); NGSI-LD API
- European Commission 2019 European Interoperability Reference Architecture, EIRA
- European Commission 2020 Core Public Service Vocabulary Application Profile
- European Commission 2020 Core Vocabularies
- European Commission 2017 Communication on The European Interoperability Framework- Implementation Strategy COM (2017) 134Annex 2
- European Commission API4Gov initiative

2.2. Shared Data Models

Goals

Guidelines and catalogue of minimum common data models in different verticals to enable interoperability for applications and systems among different cities.

Harmonised representation formats and semantics that will be used by applications both to consume and to publish data.

Data models for interoperable and replicable smart solutions in multiple sectors, starting with smart cities but also for smart agri-food, smart utilities, smart industry, etc.

Capabilities

Data models serve as a language in which systems can talk to each other. Clear, defined data models help cities in choosing and opening up data across solutions.

Data models should capture as much of the complete context they are representing as is possible. This enables other applications to define what they need for their context and request the specific attributes they are interested in.

Harmonisation across data models help in supporting different data models to again support the different applications out there. Clear definitions of data models help in transforming these data models between the different standards.

Specifications

- NGSI-LD compliant data models for aspects of the smart city have been defined by organisations and projects, including OASC, FIWARE, GSMA and the SynchroniCity project and there is an ongoing joint activity of TM Forum and FIWARE to specify more. This led to a joint effort which resulted in the smart data models: Smart Data Models – An open initiative for agile data model standardization
- Existing data models and ontologies, e.g., the SAREF (Smart Applications REFerence ontology) standard by ETSI/oneM2M, can be mapped for use with NGSI-LD by identifying what are entities, properties and relationships, which can be managed and requested by the NGSI-LD API.
- oneM2M base ontology (that is compatible with SAREF). Additionally, oneM2M provides the means to instantiate ontologies as a means to provide semantic descriptions of the data exchanged (through the use of metadata).
- SAREF: Smart Appliances REFerence (SAREF) ontology specified by ETSI OneM2M committee with the extension of SAREF4Cities provides an ontology focused on smart cities
- Core vocabularies of ISA like Core Public Service Vocabulary Application Profile used as the basis for the Single Digital Gateway Regulation that touches local governments, Core Person, Core Public Organisation, etc.
- DTDL is the Digital Twin Definition Language developed by Microsoft. This language is based on top of json-ld and the existing FIWARE data models are converted into this format.
- For spatial (and spatio-temporal) observation data, the provisions of MIM7: Geospatial information management (Places) regarding data encoding have to be taken into consideration.

3. Interaction Layer

The Interaction Layer consists of three MIMS that lay out technical specifications for knowledge and context information exchange, rules of access, use for data and services, and management of location data (OASC MIMs 1, 3, 7).

3.1. Context Information Management

Goals

Having a common catalogue of data models guarantees that we can disseminate and scale out a common data *lingua franca* based on those shared data models. Context information management enables holistic and integrated access to, use, sharing and management of data.

Capabilities

Context information is information that contains comprehensive status information about real-world entities defined in a structured way with formal definitions and provides functionalities to enable access to different data sources and analyse context information, e.g., for detecting events.

The information that cities, regions and communities possess or gather should be available and easily accessible to applications across different domains. To make the information usable, context information is key.

This will enable applications to discover the information relevant to them, for example, by specifying what is needed and retrieving or subscribing to this requested information. To share and re-use this information, an agreement needs to be in place regarding the definition of the concepts, which can be provided by data information models. This enables discovery and querying of information, both current and historical, and including geospatial information. Applications can subscribe to changes of information, so that they are always aware of the current status.

The implementation across (and even within) the city, or any application ecosystem, can be very diverse and heterogeneous. An agreement on the interfaces is necessary to be able to access the information. This is enabled by the context management API and the data models. The common data and data models are available in a catalogue and guidelines are available so that different verticals are integrated in a holistic/integrated city data lake to enable interoperability for applications and systems among different cities. The catalogue supports structural interoperability, behavioural interoperability (representation, data mappings) and governance interoperability.

Recommended specifications

- NGSI-LD, as specified by the ETSI Industry Specification Group on Context Information Management (ETSI ISG CIM), provides an API for managing and requesting context information and an underlying meta model based on entities - the core information elements, often the digital counterparts of real-world object - and their properties and relationships to other entities.
- Even though the NGSI-LD specification has been published relatively recently, there are already three Open Source implementations (Scorpio, djane and Orion-LD). Orion-LD is the NGSI-LD version of the Connecting Europe Facility (CEF) building block Context Broker.

In addition, data models are needed that are, or can be made to be, compliant with NGSI-LD:

- NGSI-LD compliant data models for aspects of the smart city have been defined by organisations and projects, including OASC, FIWARE, GSMA and the SynchroniCity project. There is an ongoing joint activity of TM Forum and FIWARE to specify more.
- Existing data models and ontologies, e.g., the SAREF (Smart Applications REFerence ontology) standard by ETSI/oneM2M, can be mapped for use with NGSI-LD by identifying what are entities, properties and relationships, which can be managed and requested by the NGSI-LD API.
- oneM2M base ontology (that is compatible with SAREF). Additionally, oneM2M provides the means to instantiate ontologies to provide semantic descriptions of the data exchanged (through the use of metadata).
- SAREF: Smart Appliances REFerence (SAREF) ontology specified by ETSI OneM2M committee with the extension of SAREF4Cities provides an ontology focused on smart cities.
- Core vocabularies of ISA like Core Public Service Vocabulary Application Profile used as the basis for the Single Digital Gateway Regulation that touches local governments, Core Person, Core Public Organisation, etc.

A relevant specification under development:

- INSPIRE: will further develop WFS3 by OGC

Verification

ETSI organized a Testing Task Force (TTF) to create a Testing toolkit to validate context brokers towards the NGSI-LD specification. The result was a set of clear defined test descriptions, test purposes and executable robot scripts. All this information can be found on the ETSI CIM Website https://www.etsi.org/comittee/cim.

References

- European Commission 2019 European Interoperability Reference Architecture, EIRA© https://joinup.ec.europa.eu/collection/european-interoperability-reference-architecture-eira/about
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- The Berlin Declaration on digital society and value-based digital government (German): https://www.bmi.bund.de/SharedDocs/downloads/EN/eu-presidency/berlin-declaration-digital-society

3.2. Ecosystem Transaction Management

Goals

Scaling of IoT- and AI-enabled services across many cities requires easy and risk-free access to suitable urban data sources that are already deployed in cities and communities today. This is the aim of this MIM.

A Digital Single Market within Europe – and extending to other areas with free-trade agreements such as Japan – would allow easy and risk-free access to relevant and available urban data, solutions and other resources so that services and solutions already deployed in other cities can easily be scaled and reach mainstream deployment. The use and re-use of the data would lead to new revenue streams, incentivising infrastructure owners to share data, analytics, services and/or solutions in infrastructure partnerships based on key technology enablers.

With a set of such marketplaces established within the European Digital Single Market, and even beyond, all parties would be able to co-create applications, solutions, services, and guidelines on top of the common data models and standardised APIs. Facilitating this ecosystem of providers and consumers would lead to sustainable business models and fair mechanisms for sharing and the provision of fair compensation, and reduce the risk for investments.

Capabilities

Such a digital marketplace would realise standardised exposure of data and data sets guaranteeing security and privacy by design. The marketplace would also realise access to services that build on this data and transform it into knowledge, intelligence and information for the consumers.

The marketplace would need to provide catalogue management, ordering management, revenue (sharing) management, SLA management, quality management and data license management.

A crucial aspect of a enabling such a marketplace is Ecosystem Transaction Management. This would need to include functionalities to enable effective matchmaking of urban IoT data sources from providers with respective data consumers, to facilitate trusted exploitation of such data based on enforceable data usage agreements and to secure value flow among these stakeholders.

There are various ways in realising such an Ecosystem Transaction Management. A standardised way of doing so is provided by the TM Forum, which has created an API suite of specifications for digital marketplaces, named the Business API Ecosystem.

Recommended specifications

- Open & Agile Smart Cities (OASC) Catalogue: http://catalogue.city
- Basic Data Marketplace Enablers https://synchronicity-iot.eu/wp-content/uploads/2018/09/SynchroniCity_D2.4.pdf
- Guidelines for the integration of IoT devices in OASC compliant platforms https://synchronicity-iot.eu/wp-content/uploads/2018/09/SynchroniCity_D2.6.pdf
- TM Forum Open APIs and component suites provide a service and technology neutral suite of APIs that provide the minimum building blocks for interoperability across all operational management areas. Each API and component suite provide the specification, reference implementations and, in most cases, conformance test kits. Reference Implementations are available under the Apache2.0 license. These APIs have gained global adoption in the Telecommunications industry and are proven to maximise reuse. They are designed to be extendable as required for specific services. The respective data models have been harmonised with FIWARE and GSMA data models. https://projects.tmforum.org/wiki/display/API/Open+API+Table
- OASC GitBook MIM3 page: https://mims.oascities.org/oasc-mim-3-contracts
- UDX (Urban Data Exchange) Catalogue: [COMING SOON]

Means of verification

- To be included

3.3. Geospatial Information Management

Goals

Specifies how to share spatial (and spatio-temporal) data, and make them interoperable with, within, and between systems and territories. This goes from static data about assets such as streetlights, buildings and streets to spatio-temporal data from sensors. The purpose of this MIM is to make this data and the way it is shared interoperable across cities, but also among stakeholders within the same city. This MIM will also provide input to MIM2: Shared Data Models, in particular regarding data which has an explicit geospatial dimension.

Capabilities

Geospatial information contains comprehensive bi-dimensional, tri-dimensional and (when time is also involved) four-dimensional representation of real-world entities defined in a structured way. Different datasets can easily be combined based on location. In addition, powerful spatial analyses and sophisticated visualisation can be performed that provide important insights to different stakeholders in the city. It is therefore essential to include the geospatial data dimension into smart city information systems.

The discovery, querying, retrieval, visualisation, and editing of geospatial information based on location and temporal criteria can be achieved through open standard formats, protocols and preferably through the use of standardised API interfaces. Integrating context information with geospatial information can be enabled by the context management API and geospatial management API through common data information models defined in the MIM2: Shared Data Models.

Specifications

The specifications that are subject to adoption are focus on web interfaces for discovery and access to data, and data encoding formats.

Web Interfaces

Specifications by the Open Geospatial Consortium (OGC)

OWS-based family of standards
These OGC Web Services standards follow the same conceptual model. They are mature, well-known by the geospatial community and supported by a wide number of client and server implementations.

- Catalogue Service for the Web (CSW)
- Web Map Service (WMS)
- Web Map Tile Service (WMTS)
- Web Feature Service (WFS)
- Web Coverage Service (WCS)
- Sensor Observation Service (SOS)

API-based family of standards
The new OGC Web API family of standards are built upon the legacy of the OGC Web Service standards to define resource-centric APIs that take advantage of modern web development practices. These new standards are web-friendly and are being constructed as "building blocks" that can be used to assemble novel APIs for web access to geospatial content. (The following OGC APIs are at a different stage of development: Features, Common, Maps, Records, Processes, Coverages, Tiles, Environmental Data Retrieval).

- The OGC SensorThings API standard provides an open source and uniform API to connect IoT devices, data and applications on the Web; it provides a standard way to manage and retrieve observations and metadata from IoT sensors built on the legacy of the OGC SOS and SPS. The SensorThings API standard supports both request-response and asynchronous transactions.
- The OGC API - Features standard provides a modular, encoding-agnostic and web-friendly means for the exposure of geospatial features on the web.

Data encoding

This section specifies data encodings for geospatial data that are also relevant for the provisions of MIM2: Shared Data Models.

Semantic 3D city models or digital twins standards for representing the entities of cities and landscapes.

- CityGML, an OGC open data model and XML-based format for the storage and exchange of virtual 3D city models
- CityJSON, a community standard, JSON-based encoding for storing 3D city models, also called digital maquettes or digital twins.
- Industry Foundation Classes (IFC), a buildingSmart open, international standard (ISO 16739-1:2018), for a standardised, digital description of the built environment, including buildings and civil infrastructure.
- ISO Observations & Measurements, providing a conceptual model for representing spatio-temporal observation data. Both JSON and XML-based implementations of the conceptual model are available. This data encoding is the default for the OGC Sensor Observation Service (xml-based), and the Sensing profile of the OGC SensorThings API.
- GeoPackage provides an open, compact and efficient format for sharing geospatial data. It is based on an SQLite database and is very well supported by both proprietary and open source software tools.

Standards for implementing European Union's INSPIRE Directive

For the European Union context, non-binding technical guidelines and good practices are available for implementing the legal provisions of the INSPIRE Directive. Technical specifications are made available for each standard, which enable data providers to choose a particular solution based on the specific needs and concrete use cases. The governance of the technical specifications is ensured by the INSPIRE Maintenance and Implementation group (MIG), and its permanent technical sub group (MIG-T). The following standards are available:

Network services

INSPIRE Network Services specify common interfaces for web services. Dedicated technical guidelines are made available for:

- Discovery Services (OGC CSW)
- View Services (OGC WMS, WMTS)
- Download Services (OGC WFS, WCS, SOS, ATOM Feeds, SensorThings API, OGC API - Features)

Data encoding

The INSPIRE data specifications define common data models, code lists, map layers and additional metadata on the interoperability to be used when exchanging spatial datasets. In addition, a dedicated Location Core Vocabulary provides a minimum set of classes and properties for describing a location represented as an address, a geographic name, or a geometry.

- GML
- GeoJSON
- GeoPackage

Means of verification

An advantage of INSPIRE is the ability to validate metadata, services and data against the technical provisions listed above, using the INSPIRE reference validator, which is fully based on open-source components. Local instances of the tool can be deployed within the cities' own infrastructures in addition to the centrally available solution.

4. Integrity Layer

The Integrity Layer consists of three MIMs focusing on the technical specifications for protection of digital rights (personal data, privacy, dignity, equality), fair AI and transparent automated decision making (societal governance of technology use and deployment), and security (systems and society).

4.1. Personal Data Management

Goals

Personal Data Management (PDM) means providing clear and easy usable means for citizens/users to control which sets/attributes they want to share with providers of solutions, applications or services under transparent circumstances, enabling trust among the different parties. Citizens should be able to identify themselves with an ID of their choice and be able

to transparently (dis)allow the service providers to access their data and control the granularity of the access (full, anonymously).

We see the following as the goals that need to be achieved:

- The right to have insight into what personal data is available, stored, shared, etc., by the providers of the applications and/or services in use;
- The right to change and/or delete part or all personal data available, stored, shared, etc., by the provider of the applications and/or services in use;
- The setting up of a “permission arrangement” indicating in which circumstances what personal data is available to which parties;
- The requesting and maintenance of consent from the users by the providers of the applications and/or services, be it governmental or businesses, that attribute-based, decentralised storage and “revealing” of personal data attributes provides full service and access to these applications and/or services;
- The creation of a centralised authentication service that aggregates public and private identity providers and creates a keychain of identifiers to be used by applications;
- The ability to initiate or revoke the consent by the users to the party;
- The right to be forgotten by services;
- The ability to know in full transparency what data is tracked and stored from a user;
- The ability to port personal data between services in different cities.

Capabilities

Personal Data Management systems need to be able to authenticate users based on a self-provided identity, linking their data in full transparency and making sure that a user can manage the data that is collected and allow service and solution providers to access the data on the terms and conditions that the users decide. In some cases, these systems need to be aligned with government initiatives like for example GDRP in Europe. Users also need to be able to determine the location and portability of their stored data, being able to choose where to store their health, insurance, or mobility data, for example.

These PDMs need to offer a machine-readable audit function so persons (and their representatives) are able to see personal data sets and activities relating to those data sets, e.g., operations involving aggregate data, like a search or analysis based on address/position/pseudo-ID), among others.

Recommended Specifications

- The MyData.org initiative that allows users to select the data operator for their data https://mydata.org/wp-content/uploads/sites/5/2020/08/mydata-white-paper-english-2020.pdf
- IHAN as testbed for fair Data economy, introduction: https://www.sitra.fi/en/projects/testbed-for-fair-data-economy-ihanfi/

Means of verification

To be included

References

- MyData Declaration and Whitepapers
- MyData Architecture and Technical Specifications
- MIM4: Personal Data Management whitepaper: Preliminary description and validation by the City of Helsinki (MIM4 Champion) and its MyData Operator, Vastuu Group https://www.mydatashare.com/oasc-mim4-specification
- MyData as MIM4 Presentation by Kimmo Karhu, Head of Data at City of Helsinki
- Ihan.fi as Testbed for Fair Data Economy and Blueprint 2.5
- Buyle, R., Taelman, R., Mostaert, K., Joris, G., Mannens, E., Verborgh, R., & Berners-Lee, T. (2019). Streamlining Governmental Processes by Putting Citizens in Control of Their Personal Data. In A. Chugunov, I. Khodachek, Y. Misnikov, & D. Trutnev (Eds.), Proceedings of the International Conference on Electronic Governance and Open Society: Challenges in Eurasia (Vol. 1135, pp. 346–359). Springer International Publishing
- Solid project and apps and Inrupt supporting the Solid project ecosystem
- On Digital Trust Infrastructure, "Proper data use in the public space" publication (in Dutch) which calls for research into a generic trust infrastructure in the public domain. In addition to recommending the inventorisation and evaluation of digital infrastructure in the public space, it encourages "investigating possibilities for the realisation of a national, impenetrable and open digital trust infrastructure for identification, authentication and authorisation of personal data, including the related governance"
- When working on project architecture and use cases, reuse I Reveal My Attributes (IRMA) architecture and apps, from the (Dutch) Privacy by Design Foundation

4.2. Transparent Artificial Intelligence (AI)

Goals

Governments, including local governments, are increasingly seeking to capture the opportunities offered by automated decision making using algorithmic systems, to improve their services. However, government agencies and the general public have justified concerns over bias, privacy, accountability, and transparency of such automated decision-making processes. New examples continue to emerge of potential negative consequences from the inappropriate use of ('black box') algorithms.

Here we define "Algorithmic System" as "software that automatically makes predictions, makes decisions and/or gives advice by using data analysis, statistics and/or self-learning logic."

An automated decision-making algorithmic system does not necessarily require any form of self-learning logic (such as machine learning). In actual practice, software is often used that does not contain any self-learning logic, but the application of which may have great and sometimes unknown or unintended impact on citizens.

To provide citizens and governments at all levels with a proper process to mitigate risk, Amsterdam City Council, along with some other cities, proposed OASC MIM5: Fair AI as part of their work to develop a European norm for procurement rules for government agencies to use when procuring algorithmic systems to support automated decision-making. Alongside this, guidance is being developed in different global regions regarding the actions that government agencies themselves need to take to assess the level of impact and to make sure that automated decision-making is trusted, fair and transparent. This will include providing channels for citizens to query the decision-making process and involving citizens in co-designing the algorithmic systems. Most importantly there is the need to ensure that the data used by those systems is accurate and appropriate, e.g., through publicly available algorithmic registries.

OASC MIM5: Fair AI will match these activities by focusing on the technical capabilities required to check that the algorithmic systems offered by the supplier comply with the requirements for fairness, trustworthiness and transparency.

Capabilities

In order to match the procurement norm being developed, the following are the set of six minimal requirements for suppliers of algorithmic systems to ensure that these are fair, trustworthy and transparent.

Procedural Transparency

- Full disclosure of the type of choices made, parties involved, risks and mitigation actions in the process of creating an algorithmic model.

Technical Transparency
- Full disclosure, to enable the buyer of the source code and model to explain the model to citizens or other stakeholders.
- Access to the learnings of the model, ideally structured using MIM2: Shared Data Models, to prevent vendor lock-in.
- Clarity about the process by which an algorithmic system makes decisions in an overall system, i.e., the optimisation goals and outcomes of an algorithm.

Technical Explainability
- Ability to explain on an individual level how a model creates certain outcomes.
- Ability to address any restrictions as to whom the information will be classified: public servants, other experts, etc.

Fairness
- Ensuring that the algorithmic systems do not systematically disadvantage, show bias against, or even discriminate against, different social groups and demographics.

Context
- However, the assessment of fairness depends on facts, events, and goals, and therefore has to be understood as situation or task-specific and necessarily addressed within the scope of practice. For instance, there may be an explicit goal to address an historic imbalance, where positive discrimination is considered appropriate. Here the aspect of “fairness” needs to be seen in the wider context.

Accountability
- Accountability for the supplier to create algorithms respecting human digital rights, and that are compliant with federal, state, and local anti-discrimination laws.
- Agencies should not procure algorithms that are shielded from independent validation and public review because of trade-secret or confidentiality claims.
- It should be noted that these capabilities should be applied differently to different systems depending on the nature, context and goals of the algorithmic system.
- Technically, these capabilities can be translated into a metadata API that every vendor would provide, when supplying high impact algorithms to cities, and the buyers could put in their requirements when procuring.

Recommended Specifications

- Danish Standards PAS DS/PAS 2500-1: 2020, Artificial Intelligence – Part 1: Transparency; DS/PAS 2500-2: 2020, Artificial Intelligence – Part 2: Decision-support usage in public administration
- ITU-T Y.4470 Reference architecture of artificial intelligence service exposure for smart sustainable cities

Means of verification

To be included

References

- Standard Clauses For Procurement Of Trustworthy Algorithmic Systems: https://www.amsterdam.nl/innovatie/digitalisering-technologie/contractual-terms-for-algorithms
- White Paper on Public AI Registers: https://algoritmeregister.amsterdam.nl/wp-content/uploads/White-Paper.pdf
- Deliverables of the European Commission AI High-Level Expert Group (AI HLEG): https://digital-strategy.ec.europa.eu/en/policies/expert-group-ai
- Presentation: democratic control over algorithms https://www.slideshare.net/OASC/fair-ai-democratic-control-over-algorithms
- Code for NL program "AI With Impact" (in Dutch)
- JRC: AI WATCH, specifically Task 6: AI in Public sector https://ec.europa.eu/jrc/en/publication/ai-watch-artificial-intelligence-public-sector
- European Commission 2019 Ethics guidelines for trustworthy AI
- On a policy level, the publication "Proper data use in the public space" (in Dutch) calls for social dialogue on AI in which a partnership is established among stakeholders including researchers, developers, policy makers and citizens. Key recommendations include:
    - Developing an Algorithm Reporting Framework (as well as a hotline)
    - Establishing a National Algorithm Register, linked to an Algorithm Forum
    - Drawing up an agenda of AI skills for trainers, politicians and policymakers
    - Exploring the impact of digitisation in the public space on the fundamental rights of citizens
    - Exploring the possibilities for certifying AI algorithms

4.3. Security Management

As cities become smarter and more technology-driven, they become a target for cyber-attacks with significant consequences in terms of costs and loss of services. In order to deliver reliable digital services for citizens, cities have to continuously evaluate the cyber risks and to put in place security measures to prepare for cyber-attacks. The objective of OASC MIM6: Security Management, accepted as Work Item during the 2020 OASC Council of Cities meeting, is to develop a methodology to help cities identify security-related risks and choose the right measures to protect their systems and data.

5. Impact Layer

The Impact Layer is driven by societal objectives with measurable outcomes towards those objectives, taking into account existing indicators, analytics, and resource management frameworks. It consists of three Work Items adopted during the OASC Council of Cities meeting on 16 June 2021 and will be developed further in their respective Working Groups. The focus for the June - December 2021 timeframe is to establish a workable baseline of references to open standards and best practices for each of these Work Items.

5.1. Ecosystem Indicator Management

Cities and towns are complex systems, and no two cities or towns are identical in the scale or scope of their complexity. In spite of this, there is increasingly clear value when cities benchmark some measurements against comparable peer cities, as well as learn from the success and failures of other cities. Innovation ecosystems are no exception. MIM8: Ecosystem Indicator Management adopted as Work Item aims to:

- Develop consistent measures of the ability of different cities to provide a healthy and effective ecosystem that nourishes digital transformation and supports interoperability of data, systems, and services;
- Govern cities' performance against these measures;
- Benchmark results and practices among comparable peer cities;
- Plan, deploy, and monitor ecosystem improvement initiatives.

5.2. Data Analytics Management

OASC MIM9: Data Analytics Management adopted as Work Item aims to make complex data models interoperable, allowing more efficient analytics and impactful exchange of expertise, to allow cities to leverage each other's successes in data analytics.

5.3. Resource Impact Assessment

OASC MIM10: Resource Impact Assessment adopted as Work Item aims to develop interoperable capabilities for management and assessment of scarcity and resources related to people, nature, and investment.