# 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 and is based on existing minimal interoperability mechanisms (MIMs) plus some additional fundamental building blocks – hence the name: MIMs Plus.[2] 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 in practice.

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;
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;
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.

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

[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

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 consists of two parts: (1) an introduction and background (Section 1) and (2) the actual specifications (Sections 2 & 3). 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 key challenges of setting up a local data ecosystem and the cross-cutting data models and architectural framework:
    - Knowledge and context information exchange,
    - Use of consistent data models,
    - Rules of access and use for data and services,
    - Protection of rights (personal data, privacy, dignity, equality, …),
    - Transparency in automated decision making (societal governance of all technology use and deployment),
    - Security (systems and society),
    - Management of location data,
    - Driven by societal objectives with measurable outcomes towards those objectives,
    - Enabling interoperability of complex data models, allowing more efficient analytics and impactful exchange of expertise,
    - Developing and using resource management frameworks.
2) European specifications and initiatives under the ‘Plus’ banner refer to e.g. EIF4SCC, ISA2, CEF, INSPIRE, EIP-SCC, ELISA, LORDI, DIGISER, and 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. The MIMs are vendor neutral and technology agnostic, meaning that anybody can use them and integrate them in existing systems and offerings, complementing existing standards and technologies.

## Reading Guide

The rest of this document is organized in three sections. The first provides an introduction to the cross-cutting Architecture Framework Model and Data Information Models, and then there is a section covering the foundational three MIMs in detail and a final section covering the rest of the MIMs.

The MIMs are each described using the following four sections:

- Goals: Identifies what the topic aims to achieve and what the 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 is outlined in the LI.EU concept paper. It is quite straight-forward: The MIMs Plus technical specifications are developed by the LI.EU Technical 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. 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 (like SAREF, OASC MIMs, INSPIRE, EIRA, OneM2M etc.) are governed by their respective governance fora.

# 2. 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 deliver 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 addresses the triple baseline of social, environmental, and economic benefits, and supports strategic aims such as the United Nations Sustainable Development Goals.

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

The group has recognised the Minimal Interoperability Mechanisms adopted by the Open & Agile Smart Cities Council of Cities6 as a relevant approach to organise the architectural 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 General Assembly on 16 June 2021. Complementary sources of potential interoperability requirements include the European Interoperability Framework[7] and the European Interoperability Reference Architecture[8].

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[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

# OASC MIMs Updated June 2022

| 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 | Capability |
| MIM8 | Indicators | OASC MIM8: Ecosystem indicator management | Work item |
| MIM9 | Analytics | OASC MIM9: Data Analytics Management | Work item |
| MIM10 | Resources | OASC MIM10: Resource Impact Assessment | Work item |

# Architectural Capabilities

The framework shown below in Fig 1 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.

To go more into detail, 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 the 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.

In an upcoming version, it is planned to establish a more elaborated and robust ontology.

A framework for such an architecture is shown below (Figure 1). In this document the following parts are further discussed:

- Data models and Context information management: Context information management realizes the Northbound open APIs and the Southbound APIs as a high-level open API. The Data models provide the harmonized models.
- Marketplace: discusses the different marketplace API and transaction management (commercial as well as non-commercial).
- Data harmonization makes sure that data models can be harmonized to shared data models and between different standards.

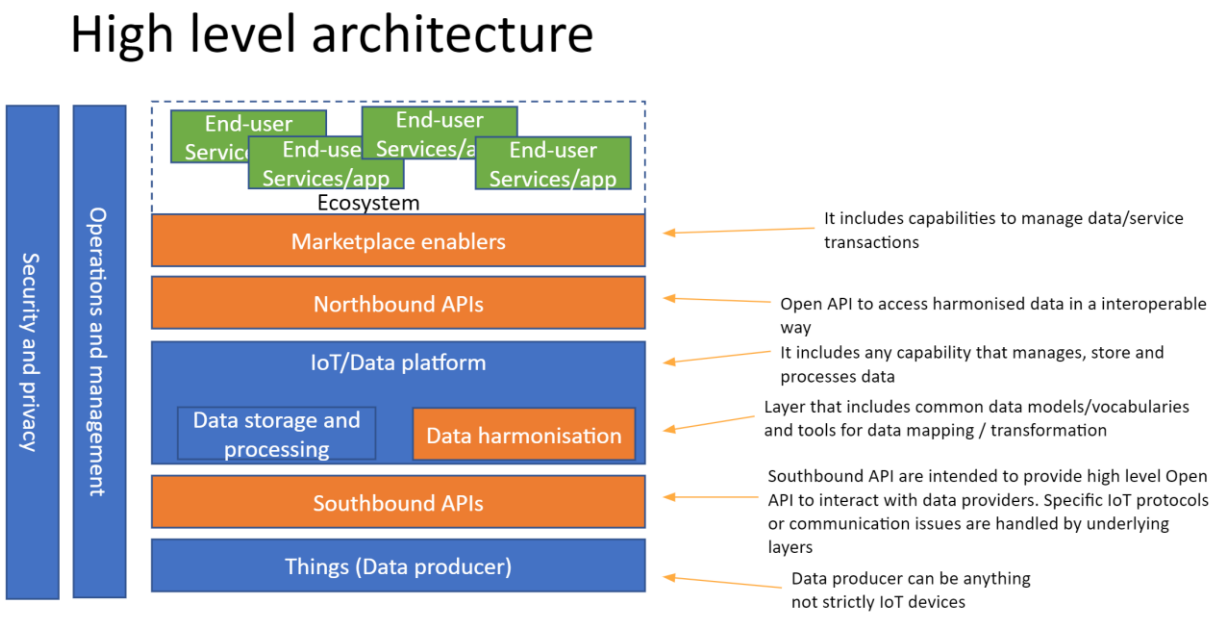



*Figure 1. High-level architecture framework model.*

## Recommended specifications and frameworks

Below is a list of specifications that are recommended:

- 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 S. 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

### Relevant European References and Specifications

- 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

# 3. The three foundational MIMs

## 3.1. MIM 1: Context Information Management

### Introduction

Context information management manages the context information coming from Internet of Things (IoT) devices and other public and private data sources, providing cross cutting context data and access through a uniform interface. It therefore ensures comprehensive and integrated access, use, sharing, and management of data across different solutions and purposes.

#### What this is about

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.

**Examples:**

To understand the information coming from many air quality sensors in the city we need to know where the sensors are located – next to a busy road, near an industrial estate, next to a hospital or place where vulnerable people are located. We also need to know other information such as - wind direction, season of the year and so on. Only then can the data be used to understand causes, decide responses, and track the effectiveness of solutions.

In order for a health centre to be able to provide effective support to a patient who has asthma, it would be useful to be able to link their address data with the fact that the address is near a busy road.

### Why this is important

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, this 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 EU Policy Context

## Problem Statement

Information coming from IoT devices etc., cannot be used effectively without knowing the context. More widely, all types of data become richer and more informative when they can be linked to the context.

An easy method is needed to access relevant context data and link it to the data produced by IoT devices and to data in general.

This needs to be common to many cities to allow benchmarking and shared learning,

## Requirements for conformance

At its core, the additional data that a data owner will want to access is data that provides useful information about the context of their own data set. To do this it needs to be possible to automatically link the relevant parts of the data in their data set with the relevant parts of the new data set.

Context information needs to use clear and accurate data models showing the properties of the entity described by the data and its relationships to other entities. See MIM2 for more details.

Appropriate APIs can then be used to link the context data appropriately with the original database.

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 key requirements are:

- Use of Data models complying with MIM2

- Use of appropriate APIs and an Information model containing …?
- The common data and data models need to be available in a catalogue, along with guidelines, 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 should support 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. See MIM2.

A relevant specification under development:

- INSPIRE: will further develop OAPIF by OGC as a driver linking to OGC APIs to enable access to complex geospatial context information that compliments the geospatial characteristics covered by NGSI-LD

## 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 clearly 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.

## Relevant European References and Specifications

- European Commission 2019 European Interoperability Reference Architecture, EIRA© https://joinup.ec.europa.eu/collection/european-interoperability-reference-architecture-eira/about
- European Commission 2020 Core Public Service Vocabulary Application Profile https://joinup.ec.europa.eu/solution/core-public-service-vocabulary-application-profile
- European Commission 2020 Core Vocabularies https://joinup.ec.europa.eu/solution/e-government-core-vocabularies/release/20
- European Commission 2017. Communication on The European Interoperability Framework- Implementation Strategy COM (2017) 134Annex 2 . Retrieved from: https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52017DC0134

- Nan Zhang, Xuejiao Zhao, and Xiaope He 2020 Understanding the relationships between information architectures and business models: An empirical study on the success configurations of smart communities Government Information Quarterly v37 (2), https://doi.org/10.1016/j.giq.2019.101439
- 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. MIM 2: Shared Data Models

## Introduction

### What this is about

In order to be able to link data sets to other sets that add important context information, it is important that the data sets being used from elsewhere use precisely the same definitions for key terms as the original dataset. For instance, if the original data set defines “children” as people aged between 5 and 15 and the other data set defines children as people between the ages of 2 and 12, then a great deal of inaccuracy would result by combining them.

More fundamentally, to enable data sets to be combined automatically, the terms used in each data set need to be defined in machine readable terms so that the APIs can “understand” how to handle them. Data models are machine readable definitions of key terms.

And finally, the data models need to be in a format consistent with MIM1 to enable Apps to link relevant context data with data sets.

## Why this is important

Having a common catalogue of Data models would guarantee that a common data lingua franca based on those shared data models can be disseminated and scaled out.

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 that capture as much as possible of the complete context they are representing enable other applications to define what they need for their context and request the specific attributes they are interested in.

Clear definitions of the data models and harmonization across data models enable data models to be re-used to support different applications.

## The EU Policy Context

## Problem Statement

To enable data sharing about any entity between different agencies in a city and different cities, there needs to be a common way of defining that entity using an agreed set of characteristics. For instance, when bringing together data relating to transport from different

sources, it is important that each data source uses the same definition of entities such as “bus”, “minibus” and “taxi”. Data models are formal ways of developing precise definitions.

If city agencies cannot easily find already agreed and defined data models relating to those entities, then each agency must invent their own.

If different agencies are using different definitions of key entities, it becomes very difficult to share information about those entities to gain a comprehensive view of what is happening in the city and very difficult for cities to learn from other cities. It also adds significant extra work as each agency needs to take time define its own set of models.

There is therefore a need to develop a common set of data models that can be used by many cities to allow benchmarking and shared learning.

## Requirements for compliance

All the entities described by data in the data ecosystem should be described by a consistent set of data models using the Resource Description Framework (RDF) methodology, Resource Description Framework Schema (RDFS), and Web Ontology Language (OWL)

For spatial (and spatio-temporal) observation data the provisions of MIM-7 (Places) regarding data encoding have to be taken into consideration.

In order to ensure wider interoperability, it is recommended that data models should all be taken from one of the relevant existing Data model initiatives, see below.

## Recommended Specifications

The preferred option is to follow the NGSI-LD compliant data models for aspects of the smart city. These have been defined by organisations and projects, including OASC, FIWARE, GSMA and the SynchroniCity project and there is an ongoing joint activity of OASC, TM Forum and FIWARE to specify more - the smart data models initiative: https://smartdatamodels.org/

Alternatively, existing data models and ontologies, 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. Some examples are as follows:

- 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 Organization 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 in this format.

## Relevant European References and Specifications

## State of play

As further work related to MIM2, it is intended to support the Smart Data Models Initiative https://smartdatamodels.org/ as an open and transparent way to develop and make available common data models. The aim is to work on the further development of:

- Guidelines and catalogue of minimum common data models in different verticals to enable interoperability for applications and systems among different cities.
- A set of harmonized 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.
- A methodology that helps translate between the credible initiatives that are developing sets of data models
- A set of guidelines on developing consistent data models
- An ever-growing catalogue of data models developed using those guidelines that are agreed by the OASC cities as the common data models that they will use

# 3.3. MIM3: Ecosystem Transaction Management

## Introduction

### What this is about

Scaling of data services, including IoT- and AI-enabled services, within cities and communities requires easy and risk-free access to suitable local data sources that are already within those communities. A local data marketplace allows for easy and risk-free access to relevant and available local data, solutions, and other resources so that new and valuable services and solutions, many of which have been already deployed in other cities can easily be implemented within the local area. The use and re-use realises new societal values, including new revenue streams, incentivising the stakeholders, including infrastructure owners, to share data, analytics, services and/or solutions in infrastructure partnerships based on key technology enablers.

MIM3 is the management layer that allows stakeholders:

- To provide data along with relevant information about its content and quality and any terms and conditions for use
- To provide data processing services along with relevant information and terms and conditions for using the services
- To find and access the data and data processing services and other services they need and to be able to gain relevant insights into what those data streams/data processing services/data applications consist of and how valuable they can be.

### Why this is important

### The EU Policy Context

## Problem Statement

Communities are increasingly seeing the need to build a local data ecosystem in order to support data sharing and the combination of different data streams to provide added insight,

However, the data relevant to the city is collected and stored by different city departments, different public sector agencies and different businesses and not for profit organisations.

It is therefore difficult:

- To find relevant data sets
- To find information about those data sets – ie their accuracy and completeness and how up-to-date they are,
- To find under what conditions are they made available
- To agree compliance with those conditions
- To access the data

## 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-trading 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 the 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

The marketplace realises standardised exposure of data and data set offerings built on standard interoperability mechanisms (e.g., those result of combining MIM1 and MIM2) and mechanisms for guaranteeing security and privacy by design. The marketplace also realises access to services offerings that build on this data and transfer it to knowledge, intelligence, and information for the consumers.

A crucial aspect of a marketplace is ecosystem transaction management. These functionalities enable effective matchmaking of relevant data sources (e.g., urban IoT data) from providers with respective data consumers, facilitate trusted exploitation of such data based on enforceable data usage agreements and secure value flow between these stakeholders.

The marketplace needs to provide a number of capabilities which may include some or all of the following:

- **Catalogue management**
  *This module provides functionalities to publish and search for different data service[9] offerings. Data offerings can be organized into groups/categories - in a hierarchical fashion when possible - to allow for an easy navigation and discovery of them. The module allows data providers to define the technical description of the data offerings they own as well as information related to the offering terms and conditions such as price, SLA, license, etc.*
- **Offers/Orders management**
  *This module allows the ordering and acquisition of data service offerings and managing acquired rights on data services. More specifically, a data consumer interested in purchasing a data service offering available in the catalogue can place an order to finalize the purchase of that digital asset. It allows the performance of operations such as subscription un-subscription, activation, deactivation, and renewal*
- **Revenue sharing management**
  *This module allows data providers to generate revenue for their offerings by charging data consumers for purchasing them. It provides tools to manage data service usage information in order to enable usage-based business models. It exposes an interface to interact with external charging platforms such as PayPal. It collects all the information required for the charging process (price, data service usage, consumer identifier, etc.), which may differ according to the pricing model associated with the data service offering and the outcome received by the external charging platform*
- **SLAs and data licenses management**
  *This module allows data service providers to set, define and customize different SLAs and licenses for data offering published on the data marketplace, thus enabling the creation of a dynamic ecosystem in which data service providers can establish various business models. It provides an interface to retrieve predefined data usage license templates so that data providers can link a data usage license instance selected among the available templates to the related data service offerings*
- **Feedback and reputation management**
  *This module provides user feedback management for the different data service offerings published on the marketplace. It also provides rating and reputation mechanisms to support data consumers in selecting the data service offerings and to promote an honest behaviour among users and providers.*
- **Party management**
  *This module covers the identification and gathering of information associated to parties involved in the exchange of data through data services and which can play the role of consumers and providers of data services. Parties can be individuals or organizations playing the role of consumers and/or providers.*
- **Customer management**

[9] With the term “data service” we include both data access and data processing services

*This module covers the identification and gathering of information about the users of the marketplace. It provides tools to manage customer information and related parties, which are the legal entities associated with the customer accounts. Depending on the access restrictions for the marketplace defined by the marketplace provider (e.g., city council, consortium, 3rd party), customers can be created and linked to specific roles (e.g., data provider, data consumer, administrator, etc.)*

- **Transparency and accountability service**
  *This module provides tools for auditing orders (including pricing model, license terms, SLAs) and tracking the parameters defined by SLAs*
- **Federation management**
  *This module manages a set of federation capabilities in accordance with the marketplace governance. Federation capabilities allow different marketplaces to interact with each other and access their resources to provide access to data offerings across them and enable the development of aggregated services*

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

## Recommended specifications

- Basic Data Marketplace Enablers https://synchronicity-iot.eu/wp-content/uploads/2018/09/SynchroniCity_D2.4.pdf
- Reference Architecture for IoT Enabled Smart Cities, Update SynchroniCity D2.10
- 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 maximize reuse. They are designed to be extendable as required for specific services. The respective data models have been harmonized with FIWARE and GSMA data models. https://projects.tmforum.org/wiki/display/API/Open+API+Table

Examples of TM Forum specifications that link with the capabilities listed above

- Catalogue management: TMF620 API, TMF633 API, TMF634 API, TMF637 API, TMF638 API, TMF639 API
- Offers/Orders management: TMF622 API, TMF641 API, TMF652 API
- Revenue (sharing) management including Payment Methods: TMF670 API, Payment Management: TMF676 API, Shopping Cart Management: TMF633 API
- SLA and data license management
- Feedback and reputation service
- Party Management: TMF632 API
- Customer management: TMF629 API
- Transparency and accountability service
- Federation management

An open-source implementation of these capabilities can be found in FIWARE (Business API Ecosystem framework) which was used in SynchroniCity and more recently in the

i4Trust project, covering data value creation building blocks for data spaces. Other examples of the implementation of these capabilities can be found in Gaia-X, IDSA data spaces, and the Indian Urban Data Xchange and the intention is to provide more detailed information about these in the next edition of MIM3

- OASC GitBook MIM3 page: https://mims.oascities.org/oasc-mim-3-contracts

### Means of verification

- To be included

### Relevant European References and Specifications

# 4. MIMs under development: MIMs 4, 5 & 7

## 4.1. MIM 4: Personal Data Management

### Introduction

MIM4 focuses on Personal Data Management in other words how to provide easy to use methods for citizens/users to control which data sets/attributes they want to share with solution, application, or service providers under transparent circumstances, enabling trust between the different parties.

There are many initiatives seeking to provide personal data management solutions, but these are primarily in the pilot or development phase, and this has led to a fragmented marketplace.

The aims of the different initiatives overlap but are not necessarily identical. Some projects focus just on personal data management, others, such as RUDI, aim to support wider data sharing ecosystems, but with personal data management being a key feature.

There are two networks of providers – MyData and Solid, which each follow different high-level methodologies. Even within each of these two networks, there are significant differences in the technical and processes used by different projects and so individual implementations are not necessarily interoperable.

There are a number of initiatives outside of these networks developing their own technical solutions.

The role of MIM4 is to identify the key capabilities required and identify pivotal points of interoperability between the different solutions to help build confidence and support implementation.

### What this is about

To provide technical and other guidance to support cities and communities to put in place the products and services that will enable their citizens to be in control of their personal data within the local data ecosystem.

To do this in a way that will make it easy to integrate with whatever credible personal data management systems their citizens may wish to use.

MIM4 will define:

- The capabilities that cities and communities need to put in place to enable citizens to have control of their data within the local data ecosystem
- The requirements to enable “good enough” interoperability between existing services and projects that offer solutions for personal data management
- Any linkages with any of the other MIMs needed to support the implementation of MIM4 into a local data ecosystem

MIM4 will also point to sets of recommended solutions that will enable cities and communities to comply with these requirements

### Why this is important

Many cities and communities would want to enable the citizen to be in charge of how the data about them is used. However, the market is still at an early stage with a variety of technical options available but only implemented at small scale. Because of this it is very risky for a city administration to commit to one or other of these options. With a key element of interoperability between them, it would be much easier to scale up the market.

### The EU Policy Context

## Problem statement

There are two networks of providers – MyData and Solid, each of which have a different high-level methodology

There is no detailed common technical and process solution even within implementations of each of MyData and Solid

There are a number of projects attempting to develop their own approach and technology solution, which have overlapping, but not necessarily identical, aims.

There is nothing available at scale – there are only individual pilots and products under development. So, this is a fragmented “marketplace” and will need some work to get it to scale.

Vastuu group has made a detailed proposal as to how the various MyData initiatives can have a minimal but sufficient level of interoperability. The work will be to see how well this will translate to the other initiatives so that a method to ensure as much interoperability as possible can be developed.

# Requirements for conformance

MIM4 will address needs and requirements from two perspectives:

- That of Individual citizens in terms of transparency & privacy preferences collection,
- That of Cities and *Data Using Services* (Data Controller/Processors/) in terms of Authorization and Data usage control and enforcement

The provisional sets of capabilities required are listed below:

**For individual citizens**

1) Citizens need to be able to choose the operator they wish to manage their data and to move from operator to operator
2) Citizens should be able to access their data through many different channels
3) Citizens should be able to use the identity of their choosing, in best cases a keychain of identities can be defined, so that users can choose the identity per service
4) Citizens should have insight what personal data is available, stored, shared, etc. by the providers of the applications and/or services they use
5) Citizens should be able to request changes to or deletion of part or all personal data available, stored, shared, etc. by the provider of the applications and/or services in use. The providers would need to comply with these requests unless there were legally justifiable reasons not to do so[10]
6) Citizens should be able to indicate in which circumstances what personal data is 'free' to use for which parties through a 'permission arrangement'
7) Citizens should be able to grant consent to 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
8) Citizens should be able to roam with their data between cities and internationally.

**For cities and Data using services**

1) Cities need to enable users to handle consent, allow and revoke access, and have full transparency on their personal data
2) Permission management needs to be handled preferably on the attribute level. Personal data processing should be described in a fine-grained manner, by covering all aspects (purposes, processing, types of data …) in a standardized manner (see as example W3C dpv: https://dpvcg.github.io/dpv/
3) Personal Data Management needs to have an open API in line with MIM1 to broker data and standard data models MIM2. Data sources need to be open and documented, and discoverable via MIM1, listing their data via MIM2. Operators may benefit from being groupable at joint initiative of cities with close ties

[10] For instance, the citizen cannot expect information regarding their age or any other key factual piece of information to be changed so as to be incorrect, specifically in a way that will affect their eligibility for services.

4) PDM systems need to manage the personal data to a high level of security. (The detail of how to do this will be dealt with by MIM6)
5) PDM systems need to be flexible enough to handle methodologies that require personal data pods to store the data as well as those that utilise personal data spaces or that allow the data to continue to be stored by the relevant organisation, but where the subject of the data is able to exercise rights as to its use.

## Recommended Specifications

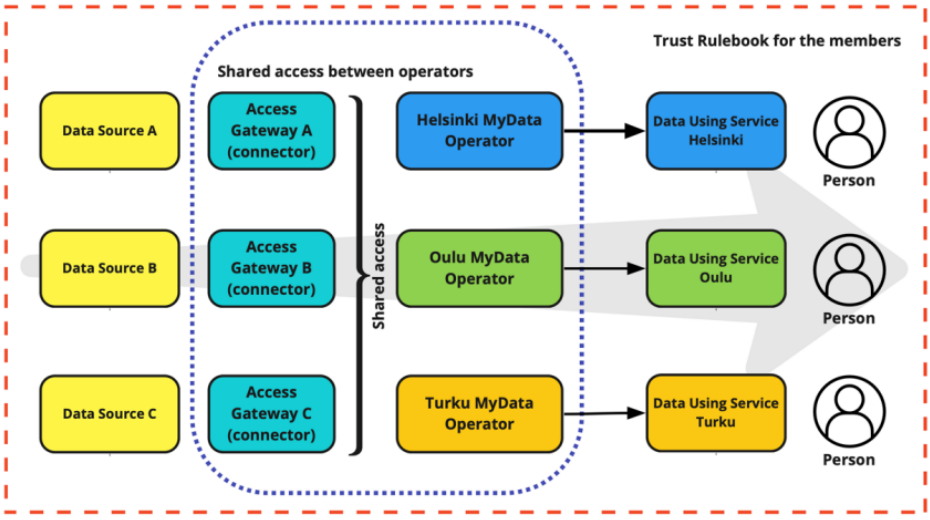
A detailed proposal for interoperability between Personal Data Management Operators was proposed to OASC in May 2021. This proposal has two pillars:

Pillar 1: One Connector for all Personal Data Management Operators

Pillar 2: Legal framework governance

The proposal is described in the paper "*Towards Interoperable Personal Data Management within Smart Cities: Minimum Interoperability Mechanism 4*" that can be accessed at: https://mims.oascities.org/mims/oasc-mim4-trust/references

Effectively, this defines a connector that enables any Personal Data Management provider that complies with the Legal agreement to be able to access data from any data source that is MIM4 compliant. In this way, each Personal Data Management provider can innovate freely around their technical solution, provided that it enables the capabilities defined in MIM4 while data providers only need to provide a single method for them to access the data.




While designed for the MyData network, the MIM4 proposal has now been reviewed in detail by MyData Global, Vastuu Group, Forum Virium Helsinki, RUDI (the Urban Data Initiative of the city of Rennes), the DataVaults and Kraken European Projects focusing on Personal Data Management and the CAPE personal data management solution developed by Engineering.

This review indicated that the proposed interoperability mechanism is a feasible way of enabling a level of interoperability between all of these and is likely to be relevant to all Personal Data Management solutions. All of the above initiatives have also agreed to work

together over the next few months to develop demos to test the proposed MIM4 Part 1 in practice.

## Means of verification

To be included

## References

- MyData Declaration and Whitepapers
- MyData Architecture and Technical Specifications
- MIM 4 white paper: Preliminary description and validation by the City of Helsinki (MIM4 Champion) and its MyData Operator, Vastuu Group.
- 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 inventorization and evaluation of digital infrastructure in the public space, it recommends "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

## Relevant European References and Specifications

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# 4.2. MIM 5: Fair Artificial Intelligence (AI)

## Introduction

MIM5 is focused on algorithmic systems that make decisions that affect the lives of citizens. Here "Algorithmic System" is defined 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.

The MIMs are about supporting cities and communities to set up an effective local data ecosystem. This is to enable them to bring together information from many areas of city life to help ensure that the city can be managed more effectively and more focused around the needs of the citizen.

AI and algorithms will have a key role in making sense of that data and some of those algorithms will be decision-making. It is therefore vital that the algorithms that use that data are fair and transparent, and that they use appropriate data from the data ecosystem appropriately to make decisions.

### What this is about

MIM 5 is about making sure that cities can have confidence that the AI and the models they use, as well as the goals the AI is programmed to achieve, are fair and transparent and that they are able to use data in a fair and transparent way. Replicability is important, as is explainability, though this last is complicated and would be handled differently for different types of AI (eg black box neural network systems will be a challenge)

MIM 5 is not restricted to algorithms that make decisions regarding the services and support to individual citizens but will also take account of AI decisions that underpin public policy and investment in the city, because these will also have significant impact on the citizens.

Cities are only beginning to use AI, but it is likely that usage will develop quickly. MIM 5 needs to provide simple, basic tools, but also take account of how things might, or should, develop to ensure it is future proofed

### Why this is important

There have already been some major scandals, where it was found that decision making algorithms were treating some communities significantly differently to others. This work is important, not merely to mitigate this risk, but also because many communities may hesitate to use AI that could benefit their citizens significantly because they cannot be confident that the decisions made would be fair.

### The EU Policy Context

It would be important to link with European implementation timetable. In about one and half years there will be many cities needing support in Europe. Funding will be available for toolboxes in the coming few months. Knowing this, some preparation work could be done to help use these opportunities in the best way to build on the work being done on MIM5. One possible option would be to put together a paper on what is needed to complement the toolbox.

## Problem statement

Governments are increasingly seeking to capture the opportunities offered by automated decision-making 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.

This is an increasingly important issue as cities and communities are increasingly using complex modelling to support their decision making and moving towards the implementation of local digital twins.

To provide citizens and governments with a proper process to mitigate risk, Amsterdam city council, the original champion of MIM5, is working with other cities to develop a European standard for procurement rules for government agencies to use when procuring algorithmic systems to support automated decision-making. Alongside this, guidance is being developed regarding the actions that government agencies themselves need to take 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.

In addition, there are some useful checklists that have been developed elsewhere, and the UK has developed a Framework on Fair AI for the Public Sector

## The Roadmap

The work is to identify/ develop a set of APIs that enable any potential algorithmic decision-making system to be queried as to:

1. Does the system use AI/ automated decision making?
    a. Yes/no,
    b. Which level?
    c. What schema is being used
2. What does the algorithms do?
    a. List of algorithms
    b. What schema is being used
3. Who certified this claim?
    a. Link to the certification
    b. A Registry of certified algorithms
    c. Schema used

And to enable the claim to be checked by comparing the results from the use of the system with the results from a known system (for instance with human decision making) to ensure the results are accurate. Here the APIs need to check both the data sets being used and the algorithms.

Alongside this, to develop relevant guidance as to how these APIs can be used.

The work would consist of:

1. Agreeing a set of definitions of key terms to ensure clarity in the work we do and as a resource to be included in MIM5

2. Developing technical tools and guidance to support cities in procuring and using fair and transparent AI. This will build on the Standard Clauses for Procurement of Trustworthy Algorithmic Systems developed by the City of Amsterdam, as well as some checklists and standards that are being gathered from around the world and that focus on the process of deciding when and how to use AI for citizen centred services. The work will involve guidance as to how cities:
    - can test whether products and services they are procuring, planning to use, or are actually using, are fair, trustworthy and transparent
    - can ensure the appropriateness and accuracy of data used both in training the algorithmic systems as well as used by those systems in decision making.

    The work could be carried out in a two-stage process.

    a) First scope out the key issues to be covered using the Amsterdam procurement guidance and other relevant checklists to scope out the technical requirements needed to support such guidance
    b) Then identify/develop a set of APIs that can automatically check whether a decision-making algorithmic system complies with the guidance document
3. Working with the agencies developing algorithmic registers, aim to align the format and process they are developing to help communities audit and keep track of their use of decision-making algorithms with the guidance and technical solutions provided in MIM5

## Requirements for Compliance

These can only be identified when the work on MIM5 is further advanced. However, 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 allow the buyer of the source code and model to enable them to explain the model to citizens or other stakeholders.
- Access to the learnings of the model, ideally structured using MIM2, to prevent vendor lock-ins.
- Clarity about the process by which an algorithmic system makes decisions in an overall system, ie. 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 is compliant with federal, state, and local anti-discrimination laws.
- Agencies should not procure algorithms that are shielded from an 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

- Amsterdam's generalized procurement conditions, along with its explanatory guide, the White Paper on Public AI Registers, and the Deliverables of the AI HLEG under the "Specifications" section provide an excellent overview of the requirements for fair, trustworthy and transparent automated decision making using algorithmic systems
- 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
- UK Framework on Fair AI for the Public Sector https://www.gov.uk/government/publications/ethics-transparency-and-accountability-framework-for-automated-decision-making/ethics-transparency-and-accountability-framework-for-automated-decision-making and Algorithmic Transparency standard https://www.gov.uk/government/collections/algorithmic-transparency-standard

## Roadmap of action linked to the model

- Links with European implementation timetable. In about one and half years there will be many cities needing support in Europe. Funding will be available for toolboxes from May 2022. Knowing this, some preparation work can be done to help use these opportunities in the best way to build on the work being done on MIM5. One possible option would be to put together a paper on what is needed to complement the toolbox.

## 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
- Machine Learning Reproducibility checklist https://www.cs.mcgill.ca/~jpineau/ReproducibilityChecklist.pdf
- The Canadian Algorithm Impact Assessment Tool https://www.canada.ca/en/government/system/digital-government/digital-government-innovations/responsible-use-ai/algorithmic-impact-assessment.html
- 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


## Relevant European References and Specifications

# 4.3. MIM 7: Geospatial Information Management

## Introduction

MIM7 aims to provide Minimal Interoperability Mechanisms related to geo-temporal data. However, there are many existing geo-temporal data standards that are of relevance to cities and to propose the full list would not be compatible with the concept of MIMs. MIM7 is therefore being developed as a number of parts.

During the work on MIM7 it has become clear that there are considerable inconsistencies between MIM7 on one hand and MIM1 and MIM2 on the other. Those inconsistencies are related both to the scope of the respective MIMs, and also due to the fact that they are based on two different ecosystems of standards that do not seem to align at the moment. The geospatial world is strongly based on the OGC ecosystem of standards, whereas MIM1 & MIM2 are based on the ETSI ecosystem of standards. In order for the three MIMs to work together for a municipality this needs to align.

MIM7 Part 1 has been developed to address this issue

### What this is about

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 Data models.

The proposed minimal requirements included in MIM7 Part 1 below will enable access to the data that is necessary to enable the above to be done.

### Why this is important

As communities are aiming to manage an ever-increasing amount of geospatial data, specifically with the move to local digital twins, it is important that they have clarity as to the first steps they need to take.

In addition, it is important to take account of the work of the Open Geospatial Consortium in migrating standards from the previous Web Services based standards family to the OGC API based family of standards https://ogcapi.ogc.org/

### The EU Policy Context

The evolution of the EU INSPIRE Directive to the new Living-in.eu digital transformation in cities and communities

## Problem statement

There is a long list of important geospatial standards and this can make it confusing for cities to understand what are the most important standards for them to adopt and which are the core requirements of those standards, that would enable minimal but sufficient interoperability to link data sets/streams in a local data ecosystem.

Specifically, to help cities transition from traditional geoportals to ones that can handled streaming data from IoT sensors

## Requirements and Recommendations

MIM7 Part 1 comprises two minimal requirements and two recommendations.

Aligned with the Rules for the structure and drafting of International Standards endorsed by the ISO and OGC OGC (see sub-clause 5.3 of [OGC 06-121r9]). The verb form “shall” indicates a requirement to be strictly followed to conform to this MIM. Recommendations, in turn, are based on good practices and ‘should’ not be strictly followed.

**Requirements.**

1. Expose data through a service interface either through OGC wfs or OGC API features
2. Ensure that all published features have unique identifiers that follow the requirements of the Inspire directive data specifications, chapter 14 Identifier management: https://inspire.ec.europa.eu/documents/Data_Specifications/D2.5_v3.4rc3.pdf or the work of W3C in the data on the web best practice: https://www.w3.org/TR/dwbp/#DataIdentifiers

**Recommendations**

1. If data is shared through wfs, a proxy OGC API could be considered on top of that
2. The use of standard-based encoding such as GeoJSON, GML, GeoPackage and CityGML

## Rationale

- MIMs are Minimal Interoperability Mechanism that should be relatively easy for cities and communities to achieve.
- The Inspire Directive, leveraging data sharing, description principles and standards like WMS and WFS, has transformed the European geospatial landscape in the last decade, and is making geodata interoperable throughout Europe.
- A main recognised challenge for European municipalities is to integrate and transfer data between internal and external IT systems.
- That most municipalities with minimal effort can establish OGC services like WFS, WMS and OGC APIs with minor investments.

- Geodata-based features need to be accessed as linked data by many IT- and IoT-systems, and over a long period of time, thus persistent identifiers are vital for the integrity of IT- and IoT-systems over time.
- For municipalities with more technical and financial strength the OGC ecosystem of standards for both geodata and sensor data are a good basis for more complex services.

Understanding that:

- The Feature and Thing (in OGC and entity in NGSI-LD) is the essential item for integrating between the two ecosystems of standards.
- That context will be created from data from various sources, for example geodata and building information models.
- A main challenge for municipalities will be to both establish and maintain the number of connections between NGSI-LD entities and their representations in the SDI (identifiers, existence, location) over time and that this process will need to be automated, most probably based on geospatial techniques like geodata or in the more complex case a digital twin.

## Means of verification

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

## Relevant European References and Specifications

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:

# 5. The remaining MIMs: MIMs 6, 8, 9 & 10

## 5.1. MIM 6: Security Management

### (Work in Progress)

### Introduction

#### What this is about

For data to be used in the data ecosystem, it may often need to go through a complex path between where it is generated and where it is finally used.

At every stage in that process, it is vulnerable to attack and proper systems need to be put in place to address this.

#### Why this is important

#### The EU Policy Context

### Problem statement

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.

### Objective

To provide cities with a framework for governance, risk management and control in the area of cybersecurity, along with a baseline of cybersecurity measures addressing the identified risks and providing a methodology for conducting regular maturity assessments.

### Relevant European References and Specifications

## 5.2. MIM 8: Ecosystem Indicator Management

### (Work in Progress)

### Introduction

#### What this is about

#### Why this is important

#### The EU Policy Context

### Problem statement

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. The Ecosystem Indicator Management MIM 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.

### Relevant European References and Specifications

## 5.3. MIM 9: Data Analytics Management

### (Work in Progress)

### Introduction

MIM 9 is very much related to Local Digital Twins. A Local Digital Twin is a representational system made up of a combination of mathematical and statistical models of dynamical systems applied to and generating discrete data sets through on or more data platforms.

However, the added value of a digital twin is not defined solely by its accuracy in representing a physical system in the highest possible detail, but rather its usefulness in a given process, e.g. bringing down cost, reducing risk, improving planning and providing better responsiveness to societal needs.

### What this is about

Local Digital Twins are territorial in scope, as opposed to digital twins focusing on sectors (e.g. energy, mobility, water) or specific technologies (e.g. edge computing), and they cover the cross-cutting issues relating to digital twins as they are linked and applied to a particular place, either physically, administratively, functionally or even culturally.

### Why this is important

MIM 9 focuses on especially the complex modeling that can happen based on cross-sectorial and linked data-driven digital twins, and thus complements the simpler geospatial needs of physical digital twins supported by MIMs 1 (context meta-data), 2 (data models), 3 (ecosystem transaction management/marketplace enablers) and 7 (geospatial information).

### The EU Policy Context

Local Digital Twins are envisioned to become a key instrument in governing and optimising living conditions for European citizens, whether in urban, peri-urban or rural areas. The focus is on delivering on concrete local goals which are felt in everyday life while taking into account more general and longer-term objectives relating to social, environmental and economic well-being. It is also a way to govern in more transparent and direct response to demand and in dialogue with citizens without losing sight of the strain on resources.

## Problem statement

The Data Analytics Management MIM 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.

## Relevant European References and Specifications

Many standards exist that are related to the registration of the physical environment, including the geospatial standards underpinning the INSPIRE (Infrastructure for Spatial Information in the European Community) directive and CityGML, an international standard for spatial data exchange issued by the Open Geospatial Consortium (OGC) and ISO/TC 211. But as the opportunity to share data across systems offers both great value and challenges to cities and communities, further work is needed, and Europe should take decisive action in this field, including but not limited to actions relating to the Interoperable Europe policy, the Digital Europe Programme, the European Green Deal, the European Missions and the European Energy Union.

## 5.4. MIM 10: Resource Impact Assessment

### (Work in Progress)

### Introduction

#### What this is about

#### Why this is important

#### The EU Policy Context

### Problem statement

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

### Relevant European References and Specifications

# Possible additional MIMs

The 10 MIMs covered here are designed to cover what is needed for a local data ecosystem that enables datasets/streams to be linked but one or two other ones may need to be added to make sure all the gaps are filled.

The process of making sure we have the full list is underway. That is important as all the MIMs have dependencies on some of the other ones, and having the full list will enable those links to be put in place

# Contributors

#### Cities

Bordeaux Métropole (France)
City of Botosani (Romania)
City of Eindhoven (Netherlands)
City of Fundão (Portugal)
City of Kavala (Greece)
City of Amsterdam (Netherlands)
City of Poznań (Poland)
City of Luleå (Sweden)
City of Nice (France)
City of Oulu (Finland)
City of Porto (Portugal)
City of Santander (Spain)
City of St. Quentin (France)
City of Tampere (Finland)
Lille Métropole (France)
City of Zaragoza (Spain)
City of Barcelona (Spain)
City of Gothenburg (Sweden)
City of Vienna (Austria)
City of Athens (Greece)

Plus the Swedish Association of Local Authorities and Regions (SALAR)

## Full list of participants

Raul-Mario Abril-Jimenez, DG DIGIT, EC
Daniel Ahlqvist, City of Luleå (Sweden)
Christophe Colinet, Bordeaux Métropole (France)
Tanguy de Lestré, OASC
Gert de Tant, OASC
Vincent Demortier, City of St. Quentin (France)
Cornelia Dinca, OASC
Juan Echevarria, City of Santander (Spain)
Iordana Eleftheriadou, DG GROW, EC
Natalia Gkiaouri, DG GROW, EC
Elias Grinias, City of Kavala (Greece)
Seppo Haataja, City of Tampere (Finland)
Lea Hemetsberger, OASC
Heikki Huhmo, City of Oulu (Finland)
Alexander Kotsev, JRC, EC
Charalampos Papadopoulos, City of Kavala (Greece)
Alex Gluhak, Urban Data Collective
Andrea Halmos, DG CONNECT, EC
Bo Baudin, Swedish Association of Local Authorities and Regions
Dirk Helbing, ETH Zürich
Franky De Leu, Digitaal Vlaanderen
Gaber Terseglav, Optifarm
Harri Honko, Vastuu Group
Ilari Mikkonen, Contrasec
Jan-Joost van Kan, Atos
Javier.Orozco-Messana, DG CONNECT
Jordi Escriu, DG CONNECT
Jordi Ortuño Ribé, City of Barcelona (Spain)
Jose Fernandez-Villacanas, DG CONNECT
Juanjo Hierro, Fiware Foundation
Linda Van De Fliert, City of Amsterdam (Netherlands)
Liviu Moron, Cybersecurity Consultant
Magnus Agnarsson, Swedish Association of Local Authorities and Regions
Marco Minghini, JRC, EC
Martin Bauer, NEC Laboratories Europe
Martin Puhar, IGEA
Meeri Haataja, Saidot
Mika Huhtamäki, Vastuu Group
Olaf-Gerd Gemein, Business Architect
Olga Dzieciatkowska, City of Poaznań (Poland)
Piotr Zaborowski, Open Geospatial Consortium
Ricardo Pinho, OASC
Roberto di Bernardo, Engineering ingegneria informatica
Sarah Gallacher, Urban Data Collective
Stafano De Panfilis, Fiware Foundation
Vincenzo Savarino, Engineering ingegneria informatica
Yasunori Mochizuki, NEC Corporation
CeesJan Mol, VentureSpring
Chandra Challagonda, Contrasec
Dimitris Kosmidis, City of Athens IT Company (Greece)
John Lynch, OASC
Cristina Martinez, DG CONNECT, EC
Nikos Mauroulis, Technopolis
Davor Meersman, OASC
Svet Mihaylov, DG CONNECT, EC
Michael Mulquin, OASC
Claudio Nanea, City of Botosani (Romania)
Serge Novaretti, DG CONNECT, EC
Stéphane Provost, Lille Métropole (France)
Morten Rasmussen, Technopolis
Stéphane Roux, City of Nice (France)
Rick Schager, City of Eindhoven (Netherlands)
Charalampos Tsitlakidis, DG CONNECT, EC
Spyridoula Vasakou, DG GROW, EC
Jaime Ventura, City of Porto (Portugal)
Barbara Viveiros, City of Fundão (Portugal)

LI.EU Tech sub-group Chair: Martin Brynskov, OASC

EC contact: Olavi Luotonen, DG CONNECT, Technology for Smart Communities unit

# Version history

| Version | Date | Main changes |
|---|---|---|
| 1.0 | October 20, 2019 | Initial draft consolidated report on technical specifications for the Digital Europe Programme and Living-in.EU (LI.EU) |
| 2.0 | December 6, 2019 | Major update in advance of the pre-launch of LI.EU in Oulu, Finland, December 10, 2019 |
| 2.1 | March 9, 2020 | Update with input from European Commission services – DIGIT, GROW perspectives |
| 2.2 | April 29, 2020 | Update before first meeting in the LI.EU Tech sub-group (May 12, 2020) – further fine-tuning of perspectives from the group |
| 2.3 | June 23, 2020 | Update before third meeting in the LI.EU Tech sub-group (June 24, 2020) – focus on Personal Data Management and Fair AI, plus adjustments from the group |
| 2.4 | July 24, 2020 | Adjustments of Personal Data Management and Fair AI |
| 2.5 | September 25, 2020 | Update on the Personal data and Fair AI |
| 3.0 | December 18, 2020 | Version release of Personal data and Fair AI |
| 4.0 DRAFT | June 23, 2021 | Update prior to the LI.EU Tech sub-group session on June 28, 2021 incorporating input from OASC Sweden and OASC following the OASC MIMs v1.0.1 update adopted by the OASC General Assembly 16 June, 2021 |
| 4.0 FINAL DRAFT | July 22, 2021 | Incorporated updated contribution from JRC regarding Geospatial Information Management (MIM 7) and Data Models (MIM 2). |
| 4.0 FINAL | | Approved by Living-in.eu Steering Board |
| 5.0 DRAFT | December 10, 2021 | Additional information sections added |
| 5.0 FINAL DRAFT | June 15, 2022 | Content of MIMs 3, 4, 5, 6, 7 and 9 updated to reflect changes to the MIMs agreed by the OASC Annual Summit |
| 5.0 | June 23 2022 | Approved by Living-in.eu Steering Board |