MIMs Plus

Living-in.EU Technical Specifications

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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 addressed 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.

In focusing on the use of common standards and technical specifications, MIMs Plus takes a pragmatic approach by developing ways to support minimal but "good-enough" interoperability by taking account of the great diversity of cities and legacy infrastructures and approaches.

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

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[1] https://www.living-in.eu/declaration

[2] Version 5.0 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

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 version 6.0 consists of three parts: (1) an introduction and background, including the Architectural Framework (2) A proposed new format for the MIMs with examples of MIMs 1,2 4 & 7 in that new format provided as alternative versions of those MIMs, and (3) section 5 providing the text for the set of MIMs as previously agreed.

MIMs Plus is based on the set of MIMs developed by Open & Agile Smart Cities then adding in references to relevant European specifications and initiatives.

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, (MIM1)
    - Use of consistent data models, (MIM2)
    - Rules of access and use for data and services, (MIM3)
    - Protection of rights (personal data, privacy, dignity, equality, …), (MIM4)
    - Transparency in automated decision making (societal governance of all technology use and deployment), (MIM5)
    - Security (systems and society), (MIM6)
    - Management of location data, (MIM7)
    - Driven by societal objectives with measurable outcomes towards those objectives, (MIM8)
    - Enabling interoperability of complex data models, allowing more efficient analytics and impactful exchange of expertise, (MIM9)
    - Developing and using resource management frameworks. (MIM10)
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?

A MIM is a description of a **Minimal** but sufficient set of capabilities that a city or community needs to achieve a certain objective to a good-enough extent, the functional and quality requirements needed to achieve those capabilities, and a description of the **Mechanisms** by which one or more different technical solutions can address those requirements.

It also provides guidance to enable as good-as-possible **Interoperability** between different mechanisms that may be used to achieve that set of capabilities.

1.1 The focus of MIMs Plus version 6.0

Version 6.0 brings in a new structure and approach to the MIMs and this is the main difference from version 5.0.

1.1.1 Why the change

- The MIMs have proved a very useful approach to supporting local community data-sharing ecosystems and the growing experience of their use has provided useful feedback as to how they can be improved.
- The growing focus in Europe on Local Digital Twins and Data Spaces means that the MIMs need to be reviewed to ensure that they are fit for purpose to support these important new initiatives.
- It has also been recognised that work on the newer MIMs was leading to inconsistencies in format and structure due to the different types of issues being tackled.
- The opportunity of much greater resources to work on developing the MIMs provided through several recent EU projects has underlined the urgent need to clarify the process for developing and structuring the MIMs, given that much of the work of developing the MIMs is now being undertaken in different project working groups that include people not familiar with the MIMs history.

1.1.2 The opportunity of working with ITU-T Study Group 20

Since January 2023, this global Standards Development Organisation has started the process of standardising the concept and format of the MIMs. This provides the opportunity to:

- Get feedback on the MIMs from a group of experts on data management who have no previous knowledge of the MIMs and so can consider them with a fresh eye.
- Work to describe and structure the MIMs in a clear and unambiguous way so that they can be properly positioned within the standards world.

This version of MIMs Plus incorporates the benefits of this valuable opportunity.

1.1.3 The status of the Individual MIMs under the new structure

Some of the existing MIMs have been tested to see how they fit into the new structure and the results have been encouraging. However:

- There has only been time to redraft a few of the MIMs into the new structure.
- Even those that have been restructured are not at a mature stage, and further work and consultation is required.

Because of this, only three MIMs are described in the new format and purely to illustrate how this new approach will work.

As none of the MIMs in the new format are yet at the stage to replace the description of those MIMs as provided in version 5.0, the descriptions of all the individual MIMs continue unchanged and can be considered to be the definitive description of the individual MIMs for this version.

The expectation is all the MIMs in whatever stage of development they have reached, will be described using the new format in MIMs Plus version 6.5 to be delivered in December 2023.

1.2 Guide to the structure of this document

The rest of this document is organized in three sections. Section 2 introduces the cross-cutting Architecture Framework Model, which remains unchanged from version 5.0. The revised concept and proposed new template for the MIMs is described in Section 3. This is followed by Section 4 using MIM 1, MIM2 and MIM4 to illustrate the new format and ending with a list of the tasks needed to take MIMs Plus to the next stage. Section 5 is an appendix providing descriptions of the MIMs in their existing format, as in the previous version of MIMs Plus.

1.3 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

2.1 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 Cities[6] 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].

2.2 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

[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

2.3 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.

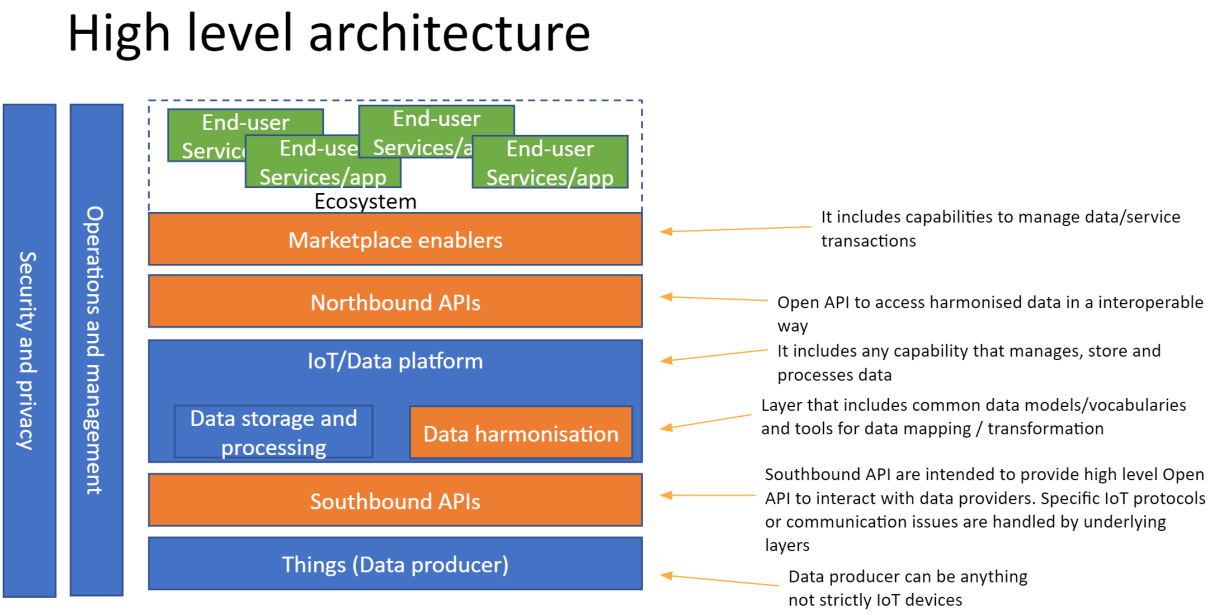


Figure 1. High-level architecture framework model.

2.4 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

2.5 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.

2.6 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

2.7 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 MIMs Concept and Structure

3.1 The role of Living-in.eu

Living-in.eu is not a standards body, but rather is focused on promoting interoperability of solutions between cities and communities throughout the EU. Its role is not to endorse one set of solutions over another, but rather to recognise that there are often many different technical solutions to tackling specific objectives, each with their own strengths and weaknesses.

In choosing between different options, communities will make decisions based on their existing resources and legacy systems and contracts. In line with the principle of subsidiarity, the focus of Living-in.eu is on providing cities and communities with information that will help them decide how best to support local data sharing, on encouraging the use of standards-based solutions and on identifying ways to support interoperability between the different solutions that might be adopted.

3.2 The need for an intermediate approach to interoperability

Interoperability is a key requirement to enable data and services to work together and to support a scalable and open market of solutions.

To address this, Standards Development Organisations are developing many comprehensive and detailed sets of standards to help cities and communities in their journey to become smart and sustainable.

However, several challenges need to be addressed:

- Cities and communities are not monolithic organisations, but consist of many autonomous or semi-autonomous agencies, both public and private, that together provide the services that enable the city to function for the benefit of the citizen. It is difficult, if not impossible, to ensure that all agencies in a city follow identical processes and standards.
- Cities and communities also are managed independently of each other and largely make decisions about how they function based on their own needs and background.
- Many cities and communities and their stakeholder organisations have contracts with technology companies that may require the use of proprietary solutions.
- There are many Standards Development Organisations, each building families of standards from different viewpoints, and these standards are not always compatible with each other.
- Finally, the very detail and complexity of the standards landscape may deter smaller cities and communities or those with limited resources from attempting standards implementation. Rather they look for good-enough solutions that they can implement quickly within their existing capabilities.

There is therefore value in an intermediate approach to interoperability; the MIMs. These focus on the core requirements of standards and thus provide a simple but solid starting place for standards implementation.

They also address the variety of technical approaches followed by different sets of standards and proprietary solutions and provide methodologies to help align these as far as practical.

In this way, cities and communities can put in place mechanisms that provide them with a “good enough” set of capabilities to get them started in gaining value from potential smart solutions and that take into account differing types of legacy infrastructure and standards ecosystems.

3.3 Minimal Interoperability Mechanisms

A MIM is a description of a common set of requirements that will provide a **Minimal** but sufficient set of capabilities that a city needs to achieve a certain objective to a good-enough extent, along with a description of the **Mechanisms** by which one or more different technical solutions addresses those requirements.

It also provides guidance to help gain a useful level of **Interoperability** between the different mechanisms that may be used to achieve that set of capabilities.

Minimal is used to describe something that can meet a specific objective with no unnecessary complexity. It is used in two senses:

1. It describes a minimal but sufficient set of requirements that will enable the user to put in place a basic implementation of what is needed to achieve a city objective and various technical solutions that will enable those requirements to be met.
2. It describes the mechanism to achieve a minimal but useful level of interoperability between two different technical solutions to achieve the same city objective and thus make it easier for date generated using different technical systems to be integrated.

The achievement of complete interoperability between two different systems often requires a great deal of work and may require a high level of expertise and time to implement. There are many circumstances, therefore, where a less than perfect level of interoperability can provide a useful first step.

Figure 2 illustrates the spectrum of levels of interoperability.

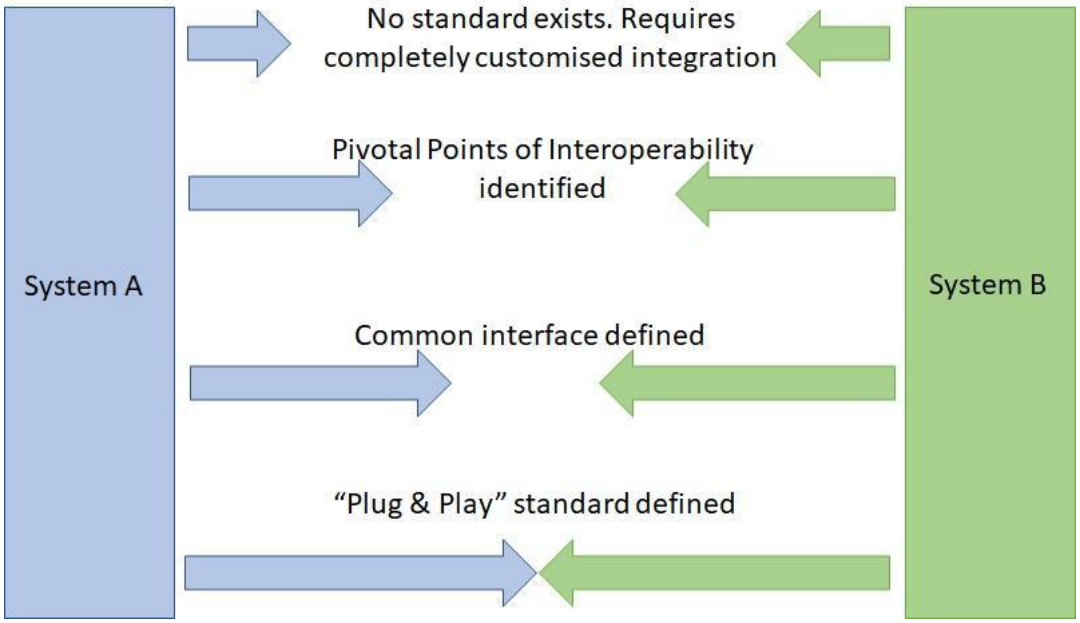


Figure 2 – Levels of interoperability

Technical solutions to delivering specific capabilities are built of components consisting of existing concepts, standards, and specifications. For instance, solutions addressing different aspects of internet-based services are likely to use component standards such as http. Where several alternative solutions to deliver the same capabilities have some of their components in common, these can form Pivotal Points of interoperability (PPIs) that can be used to simplify the effort needed to integrate them.

Another way to help integrate several alternative technical solutions is to identify the common interfaces those technical solutions use to connect to the wider systems to which they contribute. This enables the development of a common connector to that interface that can be used by each of those technical solutions. In this way, should it prove necessary, one technical solution can be swapped for another without impacting on the wider system to which it forms a part. Also, several different technical solutions can be used in parallel; providing alternative options to deliver that part of the overall system.

Both levels of "good enough" interoperability therefore minimise the effort needed to integrate between two or more different systems.

MIMs support the development of "good enough" levels of interoperability in two ways:

1. By encouraging many cities and communities to implement at least the same basic set of requirements, this will put in place the foundations for a scalable market as it will enable solutions providers to focus on products and services that deliver this same basic set.

   Because these requirements are based on subsets of the capabilities provided by more comprehensive technical solutions, the same basic level of interoperability is also possible with cities and communities that are implementing those more comprehensive sets of capabilities.

2. By identifying existing sets of technical solutions that provide mechanisms to implement the needed capabilities and by providing suggestions for methods to enable as-good-as-possible interoperability between those different sets of specifications.

3.4 The Rationale for the new structure

Living-in.eu needs to take account of the wide range of levels of resources, capabilities and objectives represented within cities and communities in the EU in supporting as good as possible interoperability between them. It also needs to recognise that there are often several different technical options to achieve common goals, each with different strengths and weaknesses.

Because of this the following methodology for developing each MIM is proposed:

- Describe the minimal set of capabilities needed by cities and communities to achieve to a good enough extent a key objective for data sharing and exploitation.
- Describe the set of functional and quality requirements needed to meet each of those capabilities. This will provide the core specifications against which conformance to the MIM can be tested.
- Identify alternative solutions that different cities are using to meet those requirements.
- Encourage proponents of each of these alternative technical solutions to describe the mechanisms each of them uses to address each of the functional and quality requirements.

By bringing together descriptions of each technical solution using a common format which is based on the list of key functional and quality requirements, the commonalities and differences between each different solution become much easier to identify. This enables:

- Ways of developing “good-enough” interoperability between the different solutions to be developed.
- An easy and helpful way to compare them that helps cities and communities decide which of them is most appropriate for them to adopt, given their specific aims, resources, competencies and legacy infrastructure and process.

3.5 MIMs Template

The proposed new format for the MIMs within MIMs Plus is as follows:

3.5.1 Objective

The first section of any MIM should be a short description of the desired outcome or outcomes of the implementation of a particular MIM, typically two or three sentences in length. This should provide the basis to make the case for implementing that MIM to the key decision makers in the city.

3.5.2 Capabilities

The Capabilities section should provide a short description of a set of core business requirements that will enable the objective to be achieved to a good-enough extent.

3.5.3 Requirements

This is the key section of the MIM, where the functional or quality requirements needed to enable the set of capabilities described in that MIM are listed. These should be clear and specific enough to enable compliance with the MIM to be tested.

Each functional or quality requirement will be derived from one or more of the Capabilities. Because of this, the capabilities and requirements are best shown together in a table.

3.5.4 Mechanisms

The Mechanisms section should provide a description of how each of one or more alternate sets of tried and tested technical solutions can deliver the functional and quality requirements covered in the MIM. These may be taken from technical specifications, formal standards documentation or may be drawn from emerging or de facto standards.

To demonstrate how the mechanism addresses the set of Requirements, each Mechanism should be shown in a table alongside the list of requirements,

3.5.5 Interoperability guidance

This section should provide a description of methods that can enable as good as possible a level of interoperability between the different mechanisms that meet the requirements covered in that MIM. This may include the identification of Pivotal Points of Interoperability and Connectors to common interfaces and guidance as to how these can be used to support integration between the different mechanisms within a specific data ecosystem.

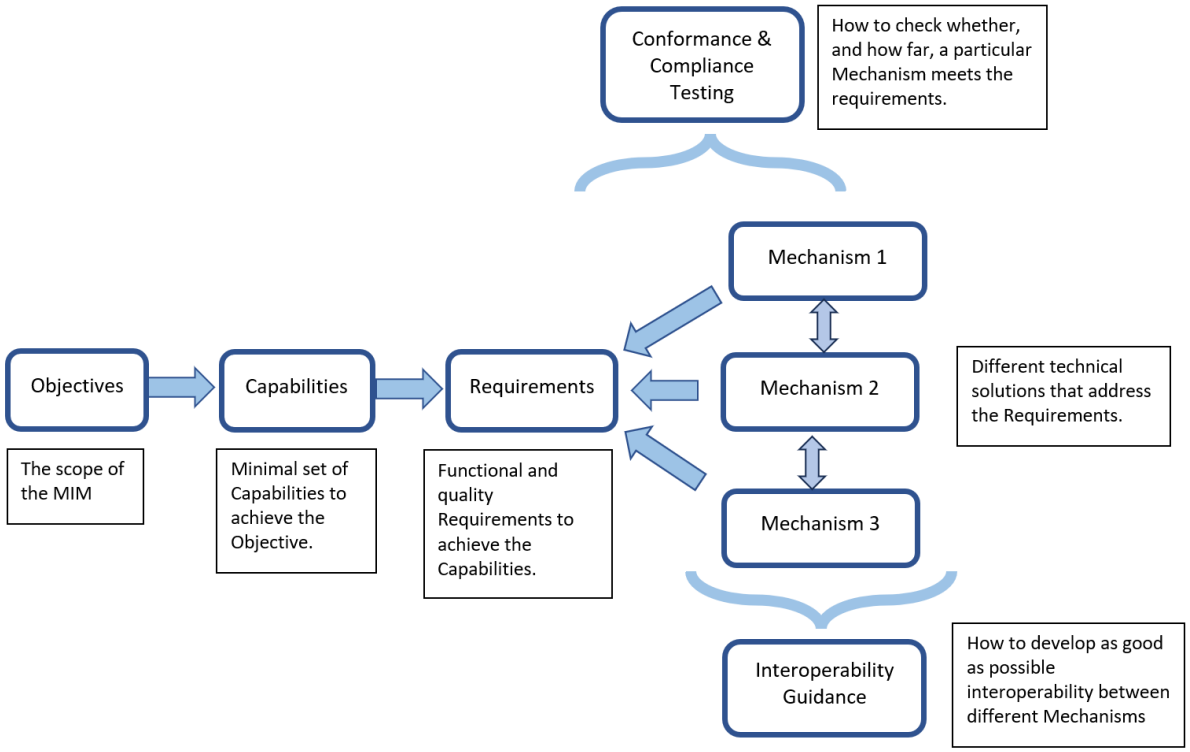
This section supports those staff responsible for integrating different technical solutions within a city or community and helps product and solution providers to design their offerings to address those different approaches.

3.5.6 Conformance and Compliance testing

Here information will be provided:

- For the delivery team to help them be sure that their implementation conforms to the MIM,
- For industry to help them know how to demonstrate that their products and services comply with the MIMs and
- For procurement officers to understand how they can check that the proposals they are assessing are MIMs compliant.

3.6 The links between the core sections of the MIM



3.7 Optional additional sections

This section may provide informative guidance regarding relevance to Public Policy, and regarding procurement and implementation. These will not be formally part of the MIM but would be designed to facilitate its implementation. They may be attached to the MIM as an annex or may be provided as separate and more detailed documentation.

4 Examples of the new format

4.1 Introduction

In this section MIMs 1, 2, 4 and 7 are provided in the new format at various levels of completeness. These still need to be widely consulted on and trialled before the final versions can be fully adopted but are offered here as alternative versions to the traditional set provided in section 5. The intention is that over the next period of time the traditional set of MIMs will be phased out.

4.2 MIM1 Context Information Management

4.2.1 Objectives

- To enable information from different systems within a city or community (energy, mobility, education & skills etc.,) and from IoT devices and other data sources, to be brought together using a uniform interface.
- To enable comprehensive and integrated use, sharing, and management of that data.

4.2.2 Capabilities and Requirements

Capabilities	**Requirements**
C1: Applications are able to access data from different sources (cities, communities, vertical solutions).	**R1**: A uniform interface shall be used; the context management API
	R2: Information from all sources shall use the same concepts, so called data information models
C2: Applications are able to use both current and historical data, use geospatial querying and be automatically updated when the source data changes.	**R3**: The uniform interface shall support retrieval of current data
	R4: The uniform interface shall support retrieval of historical data
	R5: The uniform interface shall support geospatial querying

	R6: The uniform interface shall support subscription to changes
C3: Applications can discover and retrieve data relevant to their context from a variety of sources, including from within larger data sets and with default limits and page sizes.	**R7**: Relevant data sources to any required context (at least location and time period) shall be discoverable and retrievable according to their context
	R8: Specific subsets of data relevant to the context shall be retrievable from within larger data sets and with default limits and page sizes

4.2.3 Mechanisms

Three different sets of technical specifications that can address the requirements are covered here; NGSI-LD and an Open Geospatial Consortium Standards based approach. There are likely to be other technical solutions used by cities and communities, but this section confines itself to providing a description of these two Mechanisms.

These descriptions of Mechanisms have been provided as first drafts to act as the basis for discussion and further feedback.

NGSI-LD

See https://www.etsi.org/committee/cim/ for the detailed specifications.

Requirements	**Mechanism NGSI-LD**
R1: A uniform interface shall be used; the context management API	NGSI-LD API is a uniform context management API that is provided by different context broker applications
R2: Information from all sources shall use the same concepts, so called data information models	This is provided through the common NGSI-LD information model, which is the meta model on which the API is based. The (NGSI-LD) world consists of Entities that can have Properties, Relationships etc.
R3: The uniform interface shall support retrieval of current data	From an NGSI-LD terminology perspective you would retrieve one or more Entities with their Attributes. You can restrict the Attributes to be returned as part of the Entity to those provided in “attrs”, which is

	a URI parameter. You can discover all Entities based on their characteristics by specifying their type. **The API call to use is** **GET /entities**
R4: The uniform interface shall support retrieval of historical data	Historical data is stored in the Context Broker and accessible in a similar way as the latest data can be retrieved. **The API call to use is** **GET /entities/temporal**
R5: The uniform interface shall support geospatial querying	Entities and Context Sources have location properties in GeoJSON. Entities and Context Sources can be geoqueried by specifying a georel relation such as near, within,... **The API call to use is** **GET /entities or** **GET /CSourceRegistrations**
R6: The uniform interface shall support subscription to changes	This can be done by posting a Subscription object. **The API call to use is:** **POST /subscriptions/**
R7: Relevant data sources to any required context (at least location and time period) shall be discoverable and retrievable according to their context	This can be done using a type-query **The API call to use is** **GET /CSourceRegistrations**
R8: Specific subsets of data relevant to the context shall be retrievable from within larger data sets and with default limits and page sizes	NGSI-LD is agnostic to specific pagination mechanisms but requires NGSI-LD Systems to support and define default limits and page sizes

Open Geospatial Consortium (OGC)

Requirements	**Mechanism OGC**
R1: A uniform interface shall be used; the context management API	A series of APIs for sensor data (SensorThings API), features (OGC API-Features, WFS), metadata (OGC

	API-Records) that share the same architectural pattern of the SensorThings API can be used
R2: Information from all sources shall use the same concepts, so called data information models	Semantic assets from e.g. INSPIRE as highlighted in MIM-7 that are encoded through different bindings e.g. CityGML, CityJSON, SensorThings API data model, etc.
R3: The uniform interface shall support retrieval of current data	Each API in OGC will have a different operation to implement R3, R4 and R5. In particular for OGC/INSPIRE, R5 is very powerful as this is what those services are made to do. Therefore, in order to do this properly, this should be done on a per-standard basis.
R4: The uniform interface shall support retrieval of historical data	
R5: The uniform interface shall support geospatial querying	
R6: The uniform interface shall support subscription to changes	This is currently only supported by SensorThings API through MQTT. The rest of the APIs are synchronous and not subscription-based.
R7: Relevant data sources to any required context (at least location and time period) shall be discoverable and retrievable according to their context	Achievable through OpenAPI specifications of APIs, metadata and OWS GetCapabilities for old legacy services. Discoverable through search engine is partially achieved through html encoding of data and API pagination but is still challenging.
R8: Specific subsets of data relevant to the context shall be retrievable from within larger data sets	Through queries. All APIs and legacy support this through different approaches. STA also supports MQTT.

4.3 MIM2 Data Models

4.3.1 Objective

To support cities and communities to use consistent and machine-readable definitions of all the entities about which data is being captured in a data ecosystem, along with a consistent set of identifiers of individual instances of each entity, so that data about any entity can be combined with other data referring to that entity, and every instance of that entity, in the confidence that they refer to the same thing.

4.3.2 Capabilities and Requirements

Capabilities	Requirements
C1: All entities included in data sets are described using consistent data models **to** enable interoperability for applications and systems.	R1. Data models used for all entities in any data set shall be made explicit.
	R2a. Data models should as far as possible be taken from a commonly recognised set of standardised data models as listed in section 4.2.2.1 below so that, for instance, translation engines can help align data models coming from different sources within a city/community data ecosystem. See also SEMIC Style Guide[9].
	R2b. Where it is not possible to precisely align data models, standard concepts and vocabularies should be used so that an ontology service can be used to enable a "good enough" level of consistency between them. See also SEMIC Style Guide.
	R2c: Where new data models are needed due to no suitable standardised data model being available, they shall be clearly defined using a consistent and explicit process to enable ease of transformation between the different sets of standard data models. A good process for this is provided at smartdatamodels.org, as described below in section 2. See also SEMIC Style Guide
C2: The data models used in a data ecosystem are machine readable and can be handled by the context management APIs.	R3. All key entities in any data set shall be formally defined in a machine-readable way.
	R4. Data models shall contain as much information as possible regarding their context.
	R5: Data models shall have the facility to link to data that changes over time and location, thus allowing interoperability with IoT solutions
C3: All data sets in a data ecosystem use consistent identifiers for individual instances of each entity	R6. Unique and persistent identifiers shall be used to identify particular instances of any entity used in data sets, and the type of identifier used shall be made explicit.

4.3.2.1 Standardised sets of data models

The following list provides the recommended standardised sets of data models for MIM2. This will continue to be added to, as new and suitable sets are identified.

[9] https://semiceu.github.io/style-guide/1.0.0/guidelines-and-conventions.html

1. 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. See https://smartdatamodels.org/

   NOTE 1: The initiative mentioned above provides a standardised way of developing new data models, where there is no existing model that is suitable, and thus provides an appropriate mechanism for Recommendation 2c above.

   NOTE 2: 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.
2. 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).
3. SAREF: Smart Appliances REFerence (SAREF) ontology specified by ETSI OneM2M committee with the extension of SAREF4Cities provides an ontology focused on smart cities.
4. Core vocabularies of former ISA2 (now Interoperable Europe) 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.
5. 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.
6. For spatial (and spatio-temporal) observation data the provisions of MIM-7 (Places) about data encoding have to be taken into consideration.

4.3.3 Mechanisms

Requirements	Mechanism Non-Semantic Approach
R1. Data models used for all entities in any data set shall be made explicit.	
R2a. Data models should as far as possible be taken from a commonly recognised set of standardised data models as listed in section 4.2.2.1 below so that, for instance, translation engines can help align data models coming from different sources within a city/community data ecosystem. See also SEMIC Style Guide.	Use mature data models and refrain from defining custom data models for in-house solutions.
R2b. Where it is not possible to precisely align data models, standard concepts and	Use a data model that is not technology-specific but rather

vocabularies should be used so that an ontology service can be used to enable a "good enough" level of consistency between them. See also SEMIC Style Guide.	domain-specific (and non-proprietary), and that has sufficient traction within the industry.
R2c: Where new data models are needed due to no suitable standardised data model being available, they shall be clearly defined using a consistent and explicit process to enable ease of transformation between the different sets of standard data models. A good process for this is provided at smartdatamodels.org, as described below in section 2. See also SEMIC Style Guide	Data models shall be well documented, and any instance must allow automatic validation against the specification, for instance by providing a Schema (XSD) in the case of XML, etc.
R3. All key entities in any data set shall be formally defined in a machine-readable way.	Use common serialisation formats such as JSON, XML or CSV.
R4. Data models shall contain as much information as possible regarding their context.	
R5: Data models shall have the facility to link to data that changes over time and location, thus allowing interoperability with IoT solutions	
R6. Unique and persistent identifiers shall be used to identify particular instances of any entity used in data sets, and the type of identifier used shall be made explicit.	Use Unique and persistent identifiers such as DOIs.

Requirements	**Mechanism Semantic Approach**
R1. Data models used for all entities in any data set shall be made explicit.	
R2a. Data models should as far as possible be taken from a commonly recognised set of standardised data models as listed in section 4.2.2.1 below so that, for instance, translation engines can help align data models coming from	Use an existing ontology, ideally one from the Smart Data Models catalogue[10], or from the linked open data cloud[11]

[10] https://smartdatamodels.org/

[11] http://cas.lod-cloud.net/

different sources within a city/community data ecosystem. See also SEMIC Style Guide.	
R2b. Where it is not possible to precisely align data models, standard concepts and vocabularies should be used so that an ontology service can be used to enable a "good enough" level of consistency between them. See also SEMIC Style Guide.	
R2c: Where new data models are needed due to no suitable standardised data model being available, they shall be clearly defined using a consistent and explicit process to enable ease of transformation between the different sets of standard data models. A good process for this is provided at smartdatamodels.org, as described below in section 2. See also SEMIC Style Guide	
R3. All key entities in any data set shall be formally defined in a machine-readable way.	Semantic Web ontologies are typically serialised in RDF, JSON-LD or Turtle formats, which are machine readable
R4. Data models shall contain as much information as possible regarding their context.	
R5: Data models shall have the facility to link to data that changes over time and location, thus allowing interoperability with IoT solutions	
R6. Unique and persistent identifiers shall be used to identify particular instances of any entity used in data sets, and the type of identifier used shall be made explicit.	URIs should be used as unique and persistent identifiers

4.3.4 Interoperability Guidance

Here we specify how interoperability between different implementations can be realised, for instance by making use of PPIs such as GeoJSON.

Interoperability Guidance Option 1	**Mechanism Semantic Approach**
One issue with interoperability between semantic and non-semantic data models is that	URI

semantic models require all instances to have a unique and persistent identifier. Identifiers in a non-semantic setting can use different identification schemes. One way of turning non-semantic identifiers, such as DOIs, is by prefixing them with a URI. In case of this approach, one needs to set up a "resolver" service, which can generate URIs for each entity, and allows resolving them to a page (ideally a semantic document) that provides more information about the entity and allows linking it to others.	**Mechanism Non-Semantic Approach** DOI INSPIRE
Interoperability Guidance Option 2	**Mechanism Semantic Approach**
Another great challenge in using data models is the abundance of existing models, which may describe the same or similar types of information, but do not align correctly.	Where it is not possible to precisely align data models, an ontology service, such as SKOSMOS should be used to enable a "good enough" level of consistency between data models
	Mechanism Non-Semantic Approach
	?

4.3.5 Conformance and Compliance Testing

To perform conformance testing, we highly recommend the use of the Interoperability TestBed[12] which can be tailored to the user's needs

4.4 MIM4 Personal Data Management

4.4.1 Objective

To enable citizens to be able to easily manage data about themselves so that it can enable outcomes they want, both for themselves and their community, while not compromising on privacy.

To do this in a way that will make it easy to integrate with whatever credible personal data management systems (such as forthcoming EU-registered personal data intermediary services) the citizen may wish to use.

[12] https://joinup.ec.europa.eu/collection/interoperability-test-bed-repository/solution/interoperability-test-bed/about

4.4.2 Capabilities and Requirements

There are two different types of entity that need to comply with a set of requirements to enable the objective and the basic set of capabilities to be achieved – i.e., Data holders/users and Personal Data Intermediaries (PDIs). A PDI can only manage the citizen's data if the data holders/users that hold or use that data enable the data they hold to be found and accessed by authorised PDIs and can handle the use of data coming from PDIs.

Capabilities	**Requirements for data holders and data using services**	**Requirements for Personal Data Intermediaries (PDIs)**
C1. Citizens can have insight as to what personal data is available, stored, shared, etc. by the providers of the applications and/or services they use	**Rdh1.** Personal data holders shall ensure that the data they old is documented, and discoverable.	
	Rdh2. Personal data holders shall describe and list their available data using standard data models	
	Rdh3. Personal data holders shall use an open API to enable Personal Data Intermediaries to discover and broker data	**Rpdi1.** PDIs shall make use of that common API.
C2. Citizens can have confidence that data about them is processed appropriately to manage privacy and to a high degree of security	**Rdh4.** Date holders and data using services shall describe how they process Personal data in a way that covers all aspects (purposes, processing, types of data …) in a fine-grained and standardized manner (see as example W3C dpv: https://dpvcg.github.io/dpv/	**Rpdi2.** PDIs shall describe how they process Personal data in a way that covers all aspects (purposes, processing, types of data …) in a fine-grained and standardized manner (see as example W3C dpv: https://dpvcg.github.io/dpv/
	Rdh5. Personal data holders or processors shall manage personal data to a high level of security.	**Rpdi3.** PDIs shall manage personal data to a high level of security.

C3. Citizens can 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.	**Rdh6.** Data holders or data processors shall comply with requests from the citizen relating to changing or deleting data related to themselves unless there were legally justifiable reasons not to do so[13][14]	**Rpdi4.** PDIs shall be able to handle legally justifiable requests from the citizen relating to the changing or deletion of data related to themselves and confirm that these requests were carried out by the data holders or data processors.
C4. Citizens can choose the operator they wish to manage their data and to move from operator to operator and can access their data through many different channels. They can also roam with their data between cities and internationally	**Rdh7.** Date holders shall be flexible enough to respond to Personal Data Intermediaries that use 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 original controller, but where the subject of the data is able to exercise rights as to its re-use by third party data using services.	**Rpdi5.** PDIs shall enable the citizen to easily move control of their data to another personal data intermediary, if they so wish, and shall ensure that the processes used takes account of all the different options for managing personal data.

4.4.3 Mechanisms

No examples are provided here of mechanisms that can meet these requirements as there are many alternatives for both data holders and PDIs.

For procurements, the vendors should be asked to show what mechanisms they use to enable their offerings to meet those requirements. For the development of local data spaces, participants should be required to show the mechanisms used to meet those requirements.

Requirements for data holders/users	Mechanism
Rdh1. Personal data holders shall ensure that the data they old is documented, and discoverable.	
Rdh2. Personal data holders shall describe and list their available data using standard data models	

[13] 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.

[14] GDPR, as an example, limits data subject right to data portability and right to be forgotten to a narrow subset of the 6 legal bases of processing (consent and entering a contract).

Rdh3. Personal data holders shall use an open API to enable Personal Data Intermediaries to discover and broker data	
Rdh4. Date holders and data using services shall describe how they process Personal data in a way that covers all aspects (purposes, processing, types of data …) in a fine-grained and standardized manner (see as example W3C dpv: https://dpvcg.github.io/dpv/	
Rdh5. Personal data holders or processors shall manage personal data to a high level of security.	
Rdh6. Data holders or data processors shall comply with requests from the citizen relating to changing or deleting data related to themselves unless there were legally justifiable reasons not to do so	
Rdh7. Date holders shall be flexible enough to respond to Personal Data Intermediaries that use 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 original controller, but where the subject of the data is able to exercise rights as to its re-use by third party data using services.	

Requirements for PDIs	**Mechanism**
Rpdi1. PDIs shall make use of that common API.	
Rpdi2. PDIs shall describe how they process Personal data in a way that covers all aspects (purposes, processing, types of data …) in a fine-grained and standardized manner (see as example W3C dpv: https://dpvcg.github.io/dpv/	
Rpdi3. PDIs shall manage personal data to a high level of security.	
Rpdi4. PDIs shall be able to handle legally justifiable requests from the citizen relating to the changing or deletion of data related to themselves and confirm that these	

requests were carried out by the data holders or data processors.	
Rpdi5. PDIs shall enable the citizen to easily move control of their data to another personal data intermediary, if they so wish, and shall ensure that the processes used takes account of all the different options for managing personal data.	

4.4.4 Interoperability Guidance

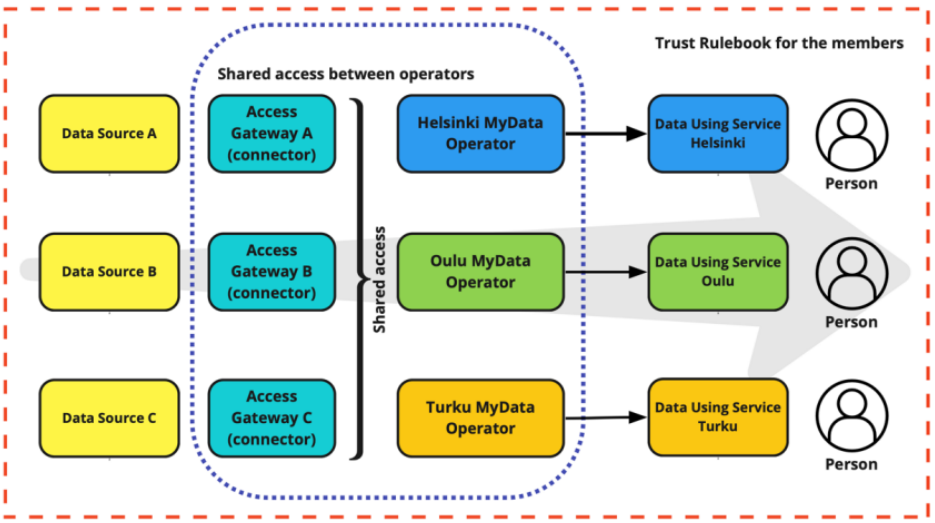
A detailed proposal for interoperability between Personal Data Intermediaries has been agreed. This proposal has two pillars:

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 Intermediary that complies with the Legal agreement and belongs to a particular trusted group of data intermediaries to provide access to data from any data source that is MIM4 compliant. In this way, each Personal Data Management provider can innovate freely around their technical solution for providing data access control to the citizens, provided that data source enables the connector capabilities defined in MIM4. This allows serving the data out via multiple access control mechanisms as needed, while any personal data intermediary provider only needs to provide a single method for the data using services/applications to access the data.



4.4.5 Conformance and Compliance

This will be provided in the next version.

4.5 MIM7 Spaces

4.5.1 Objective

To enable cities and communities to easily integrate static data about assets such as streetlights, buildings, and streets with spatio-temporal data from sensors, along with other data sources that can provide helpful context information to the geospatial data, and make the data interoperable within, and between cities and communities.

4.5.2 Capabilities and Requirements

Capability	Requirement
C1. Cities and communities can easily integrate and transfer geospatial related data between internal and external (IoT related) IT systems	R1. Data shall be exposed through a service interface either through OGC wfs or OGC API features. If data is shared through wfs, a proxy OGC API could be considered on top of that.
C2. Cities and communities can integrate spatially related data coming from a variety of sources, for example geodata, building information models and IFC.	R2. Standards-based encoding such as bSI Standards: Industry Foundation Classes (IFC – ISO 16739-1:2018), BIM Collaboration Format[15] (BFC) and Industry standard Application Programming Interfaces (BFC API) shall be used
C3. Cities and communities can integrate spatially related data with other data that can provide further information about the context	R3. All data sets used shall comply with MIM1 and MIM2.
C4. Cities and communities have a consistent and persistent way of describing individual instances of all entities included in the geospatial data that they collect	R4. All published features shall have unique identifiers that follow the requirements of the Inspire directive data specifications, chapter 14 Identifier

[15] https://www.buildingsmart.org/standards/bsi-standards/bim-collaboration-format-bcf/

	management[16] or the work of W3C in the data on the web best practice[17].
C5. Cities and communities can share spatial data within, and between cities and communities in the confidence that they are interoperable.	R5. Standards-based geospatial encoding such as GeoJSON, GML, GeoPackage and CityGML shall be used.

4.5.3 Mechanisms

No examples are provided here of mechanisms that can meet these requirements as there are no specific packaged up approaches to deliver MIM7.

For procurements, the vendors should be asked to show what mechanisms they use to enable their offerings to meet those requirements.

4.6 Development Roadmap for MIMs Plus v. 6.5 and beyond

The following tasks were agreed at the Living-in.eu tech subgroup meeting on 15th June 2023:

- Develop the framework to take account of this new approach.
- Build on the first drafts of MIMs 1 & 2 to gain consensus on the Objective, the core set of Capabilities and the Requirements and how the different mechanisms address the Requirements.
- Update MIM3, 4 and 7.
- Work on MIM5 in partnership with the CommuniCity and CitCom.ai initiatives and on MIM6 with CitCom.ai.
- Review the implications of Data spaces, LDTs and the CitiVerse on the MIMs
- Work on compliance testing and procurement guidance.
- Engage with integrators that manage digital operations on behalf of the cities to identify how to best work with them.
- Use projects to test methods to best address issues such as the business models, legal questions etc.
- Develop Implementation guidelines
- Engage with Interoperable Europe Board, to gain the certification needed for MIMs to become part of the ecosystem to implement Interoperable Europe
- Continue to build on the international standardisation work of ITU

[16] https://inspire.ec.europa.eu/documents/Data_Specifications/D2.5_v3.4rc3.pdf

[17] https://www.w3.org/TR/dwbp/#DataIdentifiers

5 The existing set of MIMs in the current format

5.1 MIM 1: Context Information Management

5.1.1 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.

5.1.2 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.

5.1.3 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.

5.1.4 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,

5.1.5 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.

5.1.6 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

5.1.7 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.

5.1.8 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

5.2 MIM 2: Shared Data Models

5.2.1 Introduction

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

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

Smart Data Models for interoperable and replicable smart solutions in multiple sectors, starting with smart cities but also for smart agrifood, smart utilities, smart industry, etc.

5.2.2 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.

5.2.3 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.

5.2.4 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.

5.2.5 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.

5.2.6 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.

5.2.7 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

5.3 MIM3: Ecosystem Transaction Management

5.3.1 Introduction

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 realizes 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.

5.3.2 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

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- 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.

5.3.3 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

5.3.4 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.

5.3.5 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[18] 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

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

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

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.

5.3.6 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

5.4 MIM 4: Personal Data Management

5.4.1 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.

5.4.2 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

5.4.3 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.

5.4.4 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.

5.4.5 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[19]
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
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)

[19] 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.

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.

5.4.6 Recommended Specifications

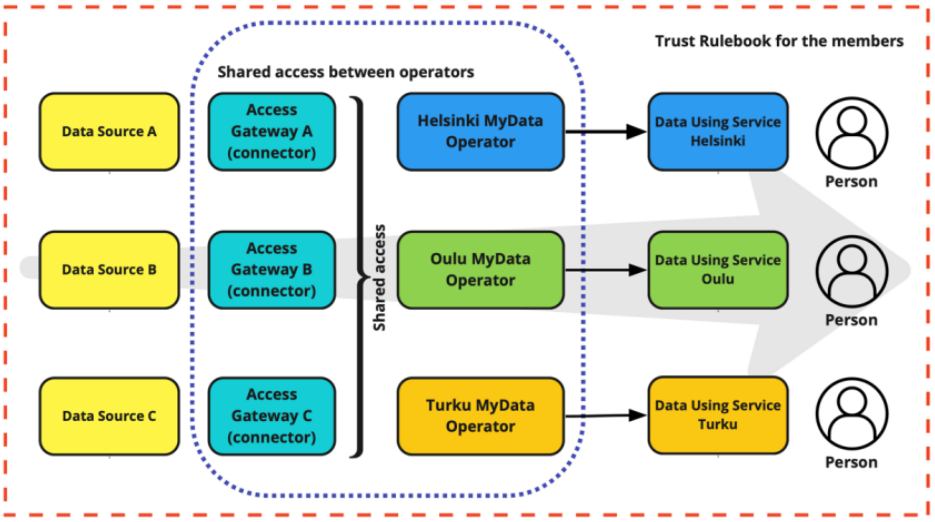
A detailed proposal for interoperability between Personal Data Management Operators was proposed to OASC in May 2021. This proposal has two pillars:

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.

5.4.7 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

5.5 MIM 5: Fair Artificial Intelligence (AI)

5.5.1 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.

5.5.2 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

5.5.3 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.

5.5.4 The EU Policy Context

It would be important to link with the 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.

5.5.5 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

5.5.6 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

5.5.7 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.

5.5.8 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

5.6 MIM 7: Geospatial Information Management

5.6.1 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

5.6.2 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.

5.6.3 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/

5.6.4 The EU Policy Context

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

5.6.5 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

5.6.6 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

5.6.7 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.

5.6.8 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.

5.6.9 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:

5.7 MIM 6: Security Management

(Work in progress)

5.7.1 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.

5.7.2 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.

5.7.3 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.

5.8 MIM 8: Ecosystem Indicator Management

(Work in Progress)

5.8.1 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.

5.9 MIM 9: Data Analytics Management

(Work in Progress)

5.9.1 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.

5.9.2 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.

5.9.3 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).

5.9.4 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.

5.9.5 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.

5.9.6 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.

5.10 MIM 10: Resource Impact Assessment

(Work in Progress)

5.10.1 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.

6 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

7 Contributors

All that attended the Living-in.EU Tech Subgroup Meeting on 24.05.2023 and 15.06.2023 that are (but not limited to):

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7.2 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
5.5	May 24 2023	Approved by Tech Subgroup
6.0	June 15 2023	Approved by Tech Subgroup