Proposals re the MIMs

For Annual Summit 14th June 2023

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Background

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The opportunity of significant new resources

The big change for this year is that several new projects and initiatives have started or are about to start that are funded by the European Commission with tasks that include helping to develop the MIMs.

- This added resource means that we will be able to progress much faster with the MIMs over this coming year.
- However, OASC faces the challenge of coordinating this activity.

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The revision of the MIMs concept and structure

The main change from the MIMs reviewed in the Annual Summit last year is that most of the work has been on clarifying the description of the MIMs concept and the template for the individual MIMs.

This revision forms the focus of the decisions required at this Annual Summit.

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Why the Review of the concept & structure?

- The growing experience of using the MIMs has provided useful feedback as to how they can be improved.
- Work on the newer MIMs was leading to inconsistencies in format and structure due to the different types of issues being tackled.
- The MIMs need to be reviewed to ensure that they are fit for purpose for Local Digital Twins, Data Spaces and the Citiverse.
- **A clearly defined process for developing and structuring the MIMs is needed as much of the work of developing the MIMs will be done with the help of different projects that include people not familiar with the MIMs' history.**
- The ITU has started the process of standardising the concept and format of the MIMs. This helps:
    - Get feedback on the MIMs from a group of experts on interoperability related to data management and sharing who have no previous knowledge of the MIMs and so can consider them with a fresh eye.
    - Ensure that the MIMs concept and structure are described in a clear and unambiguous way so that they can be properly positioned within the world of standards.

The rationale for the new approach

- The role of OASC
- The need for an intermediate approach to interoperability

The role of OASC

OASC is not a standards body. The mission of OASC is to unite cities around the world to build a global market for smart city data and services from the demand side and based on the needs of cities and communities.

Therefore, it aims to promote interoperability of solutions between cities and communities around the world. This must take account of the fact that cities can choose between different technical approaches to tackling any city/community objective, each with its own strengths and weaknesses.

In choosing between different options, cities and communities will make decisions based on their resources, legacy systems, and existing contracts with suppliers.

The key role of OASC is therefore to identify the range of viable solutions that cities can use to tackle key objectives related to data use and ways to support interoperability between these different solutions.

The standards landscape is complicated

There are many Standards Development Organisations, each building families of standards from different viewpoints, and these standards are not always compatible with each other.

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The complexity of cities

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.

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The independence of cities

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.

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The use of proprietary solutions

Many cities and communities and their stakeholder organisations have contracts with technology companies that may require the use of proprietary solutions.

The complexity of standards

Finally, the very detail and complexity of standards 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.

“Good-enough” interoperability

There is therefore value in an intermediate approach to interoperability; the MIMs.

- These focus on the core requirements needed to achieve city objectives and thus provide a simple but solid starting place.
- 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 “good enough” mechanisms to get them started in gaining value from potential smart solutions and that address the variety of types of legacy infrastructure and standards ecosystems.

The proposed new format for the MIMs

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The proposed new description of a MIM

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, 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.

What do we mean by “Minimal”?

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 useful set of requirements that will enable the user to put in place a basic implementation of what is needed to achieve a city objective.
2. It describes guidance to achieve a minimal but good-enough level of interoperability between different technical solutions to achieving the same city objective.

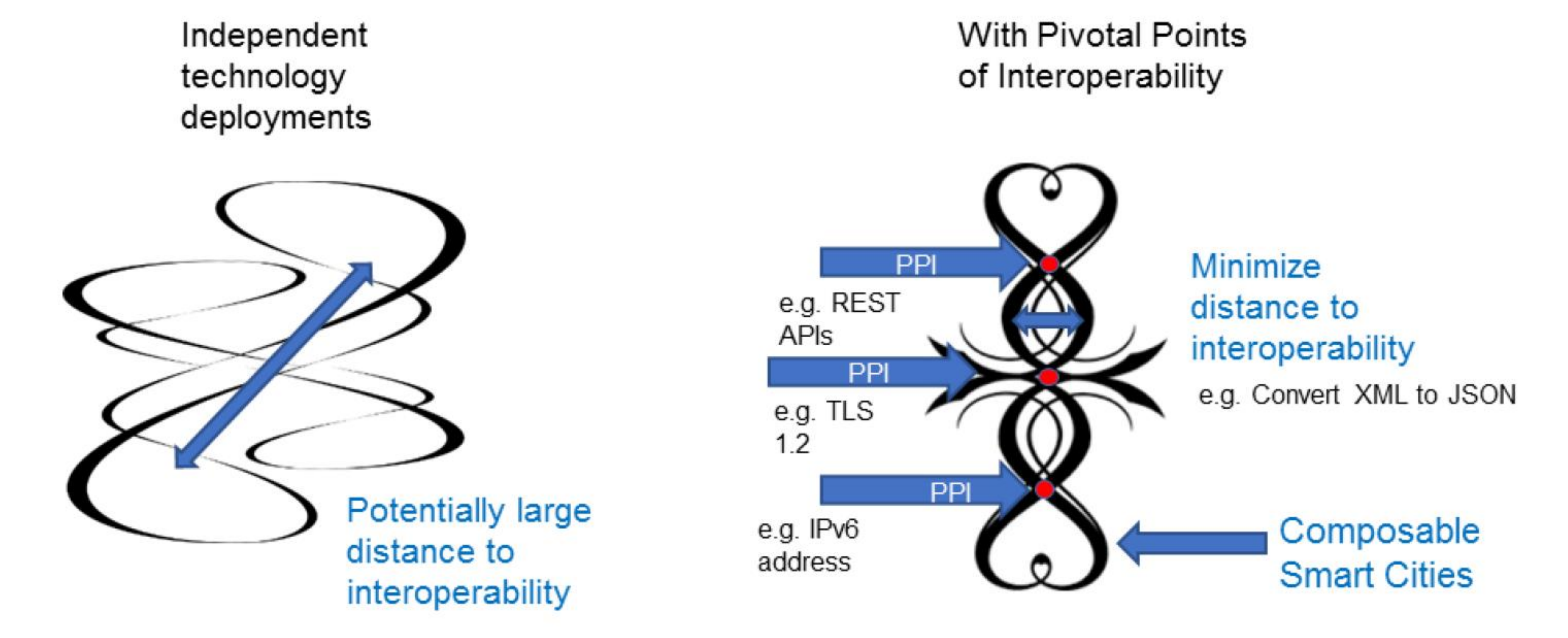
“Good-enough” interoperability

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.

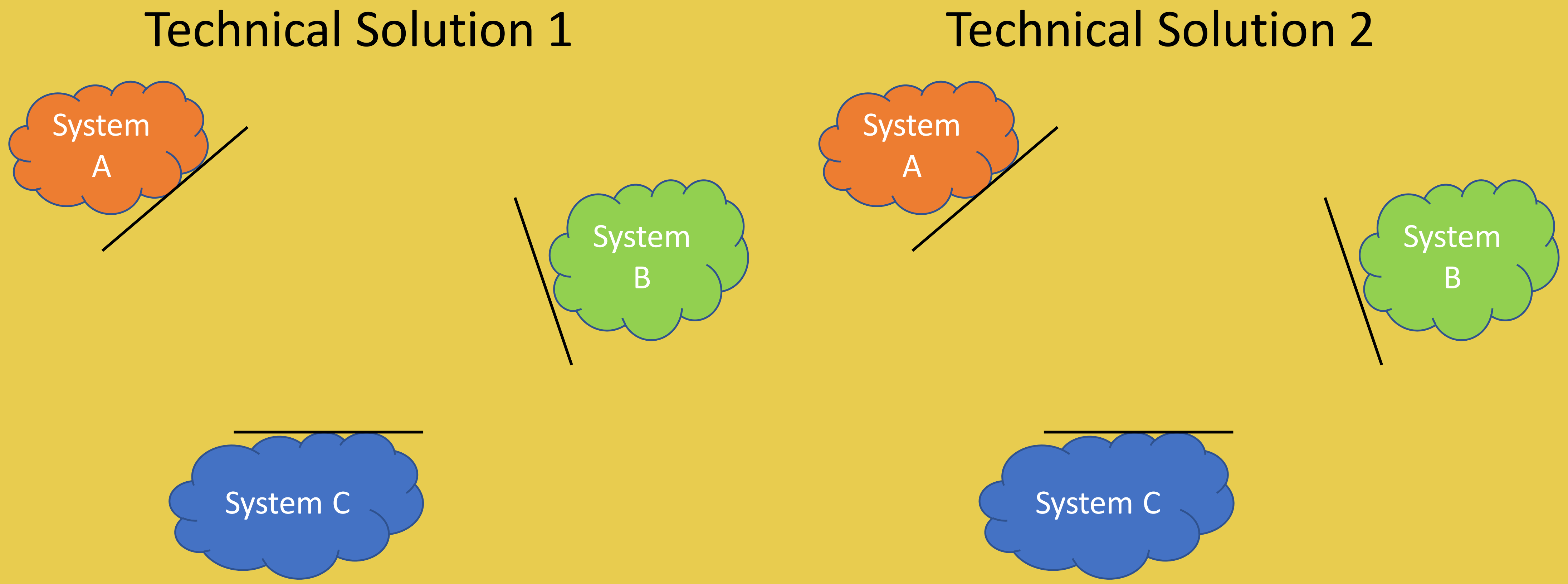
   Because these requirements are based on subsets of the capabilities provided by more comprehensive technical solutions, the same basic level of interoperability is also possible with cities and communities that are implementing those more comprehensive sets of capabilities.
2. By identifying existing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

Pivotal Points of Interoperability



Often within different technology approaches, some concepts and component standards are common. For example, most smart city applications make use of the Internet standards as the technology choice for exchanging information. Such common component standards can be considered as “Pivotal Points of Interoperability” and if these PPI are known, developing interoperability between divergent systems is simplified.

Connectors



Where the different technical solutions need to link to other systems, common Connectors can be developed

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The proposed new format for each MIM

Objectives	The Objectives sets the scope for the MIM by describing at a high level what it aims to achieve.
Capabilities	The Capabilities section describes a minimal but sufficient set of business requirements that will deliver the Objectives to a good-enough level and in a way that is within the resources of most cities.
Requirements	The Requirements section describes the functional and quality requirements that are needed to deliver the agreed minimal set of Capabilities.
Mechanisms	The Mechanisms section identifies technical solutions that address the set of requirements and are already in use by cities and communities. It provides the opportunity for proponents of each solution to describe the mechanisms by which that solution addresses each of the requirements.
Interoperability Guidance	The Interoperability Guidance section uses the descriptions of the Mechanisms provided by different technical solutions to identify where those solutions use common base standards or where processes link to common interfaces. It then describes options to support interoperability between them, either by describing existing ways of doing this, or by scoping out the work that is needed to develop them.

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The status of the MIMs under the new structure

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The present situation

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 redrafted are not at a mature stage, and further work and consultation is required.

Because of this only examples of MIMs in the new format are provided, to illustrate how this new approach will work. The General Assembly is therefore not being asked to agree the text of even these MIMs but to endorse the general approach, in the expectation that mature versions will be brought to the Annual Summit in 2024

MIM1: Context information management

- MIM1: *Context Information Management* is described in the new format to illustrate how the Objectives lead to Capabilities and the Capabilities lead to functional and quality Requirements and then to show how the mechanisms by which alternative technical approaches address those requirements can be described.
- This is the first draft of MIM1, and this will continue to be developed and refined over the next few months.
- The sections on interoperability mechanisms and conformance testing are not included as these are still in early draft.

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MIM1 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.

MIM1 Capabilities and Requirements

Capabilities	Requirements
C1: Applications are able to access data from different sources (cities, communities, vertical solutions).	R1: A uniform interface should be used; the context management API
	R2: Information from all sources should 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 should support retrieval of current data
	R4: The uniform interface should support retrieval of historical data
	R5: The uniform interface should support geospatial querying
	R6: The uniform interface should support subscription to changes
C3: Applications can discover and retrieve relevant data sources related to their context, including from within larger data sets.	R7: Relevant data sources to any required context (at least location and time period) should be discoverable and retrievable according to their context
	R8: Specific subsets of data relevant to the context should be retrievable from within larger data sets and with default limits and page sizes

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MIM1 Requirements and Mechanism NGSI-LD

Requirements	Mechanism NGSI-LD
R1: A uniform interface should 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 should 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 should 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 should 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 should 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 should 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) should 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 should 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

MIM1 Requirements and Mechanism OGC

Requirements	Mechanism OGC
R1: A uniform interface should 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 should 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 should 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 should support retrieval of historical data	
R5: The uniform interface should support geospatial querying	
R6: The uniform interface should 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) should 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 should be retrievable from within larger data sets and with default limits and page sizes	Through queries. All APIs and legacy support this through different approaches. STA also supports MQTT.

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<table>
<tr><th>Requirements</th><th>Mechanism RDF</th></tr>
<tr><td>R1: A uniform interface should be used; the context management API</td><td>A semantic triple, or RDF triple or simply triple, codifies a statement about semantic data in the form of subject–predicate–object expressions, each addressable via a unique URI’s.
Context is thus provided automatically using the subject–predicate–object expression.</td></tr>
<tr><td>R2: Information from all sources should use the same concepts, so called data information models</td><td>RDF is the atom of information (whereas ERD models are molecules) with a minimum of structure. Context is provided in the same way as other types of data and/or metadata.

Basic vocabularies are provided by RDFS (RFD Schema) which allows for hierarchy of classes and properties. Additionally, OWL extends RDFS by adding more advanced constructs.

RDF validation against a set of conditions is done through SHACL.

The entire RDF stack is managed in an open process by W3C and ISO.</td></tr>
<tr><td>R3: The uniform interface should support retrieval of current data</td><td rowspan="3">SPARQL is an RDF query language.

Historical data retrieval uses the same pattern as retrieving any other type of data.

Spatial querying is done through GeoSPARQL, managed by the OGC. The GeoSPARQL standard follows a modular design; it comprises several different

components.

- A core component defines top-level RDFS/OWL classes for spatial objects.

- A topology vocabulary component defines RDF properties for asserting and querying topological relations between spatial objects.

- A geometry component defines RDFS data types for serializing geometry data, geometry-related RDF properties, and non-topological spatial query functions for geometry objects.

- A geometry topology component defines topological query functions.

- An RDFS entailment component defines a mechanism for matching implicit RDF triples that are derived based on RDF and RDFS semantics.

- A query rewrite component defines rules for transforming a simple triple pattern that tests a topological relation between two features into an equivalent query involving concrete geometries and topological query functions.</td></tr>
<tr><td>R4: The uniform interface should support retrieval of historical data</td></tr>
<tr><td>R5: The uniform interface should support geospatial querying</td></tr>
<tr><td>R6: The uniform interface should support subscription to changes</td><td>RDF triples follow the same pattern as any distributed Pub/Sub interaction scheme (including MQTT).</td></tr>
<tr><td>R7: Relevant data sources to any required context (at least location and time period) should be discoverable and retrievable according to their context</td><td>Data discoverability and cataloguing done through the DCAT (DCAT is an RDF vocabulary designed to facilitate interoperability between data catalogues published on the Web).</td></tr>
<tr><td>R8: Specific subsets of data relevant to the context should be retrievable from within larger data sets and with default limits and page sizes</td><td>Triples form a loosely coupled distributed dataset and can be retrieved as a graph, based on the query – either for sub-setting or further querying.</td></tr>
</table>

MIM2: Data Models

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, so that data about any entity can be combined with other data referring to that entity in the confidence that they refer to the same thing

MIM2 Capabilities and Requirements

Capabilities	Requirements
C1: Cities and communities can draw on catalogues of common vocabularies and minimum common data models in different verticals to enable interoperability for applications, and systems.	R1. As far as possible, data models should be taken from a list of standard specifications. Use common concepts and vocabularies.
C2: The data models used in a data ecosystem can be handled by the context management APIs.	R2. All key entities in any data set should be formally defined in a machine-readable way.
	R3. Data models should contain as much information as possible regarding their context.
	R4: Data models should be in a format consistent with MIM1.
C3: Data models based on different standards can be aligned.	R5: Data models should be clearly defined using a consistent process to enable ease of transformation between the different sets of standard data models.
	R6: Translation engines should be developed/identified to enable data models from different standards to be aligned.

MIM2 Mechanism Non-Semantic World

Requirements	Mechanisms Non-Semantic Approach
R1. As far as possible, data models should be taken from a list of standard specifications. Use common concepts and vocabularies.	Use a data model that is not technology-specific but rather domain-specific (and non-proprietary), and that has sufficient traction within the industry.
R2. All key entities in any data set should be formally defined in a machine-readable way.	Use common serialisation formats such as JSON, XML or CSV.
R3. Data models should contain as much information as possible regarding their context.	Use mature data models and refrain from defining custom data models for in-house solutions.
R4: Data models should be in a format consistent with MIM1.	
R5: Data models should be clearly defined using a consistent process to enable ease of transformation between the different sets of standard data models.	Data models should 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.
R6: Translation engines should be developed/identified to enable data models from different standards to be aligned.	Maintain mapping tables and document similarities with properties in similar or related data models.

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MIM2 Mechanisms Semantic Web

Requirements	Mechanisms Semantic Approach
R1. As far as possible, data models should be taken from a list of standard specifications. Use common concepts and vocabularies.	Use an existing ontology, ideally one from the Smart Data Models catalogue, or from the Linked Open Data Cloud.
R2. All key entities in any data set should 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.
R3. Data models should contain as much information as possible regarding their context.	Semantic Web ontologies should be linked together, thus creating a complex web of data where the relations of properties between different ontologies.
R4: Data models should be in a format consistent with MIM1.	
R5: Data models should be clearly defined using a consistent process to enable ease of transformation between the different sets of standard data models.	A governance scheme should be put in place to make sure ontologies are maintained consistently.
R6: Translation engines should be developed/identified to enable data models from different standards to be aligned.	In a semantic web setting, this means linking together different ontologies. This is a task that is often neglected because there is no clean ownership of the "space in between" ontologies.

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MIM2 Interoperability Mechanisms

Interoperability Mechanism 1	Mechanism Semantic Approach
One issue with interoperability between semantic and non-semantic data models is that 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 URI’s 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.	Uniform Resource Identifier (URI) **Mechanism Non-Semantic Approach** DOI Digital Object Identifier INSPIRE
Interoperability Mechanism 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** ?

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MIM4 Interoperability Mechanisms

While much further work still needs to be done on the Objectives, Capabilities, Requirements and Mechanisms for MIM4, it is included here to illustrate the Interoperability Mechanism, as this is at a high level of maturity in this MIM.

MIM4 Objectives

- 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 (such as forthcoming EU-registered personal data intermediary services) their citizens may wish to use.

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Interoperability Mechanism

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 Intermediaries
- 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

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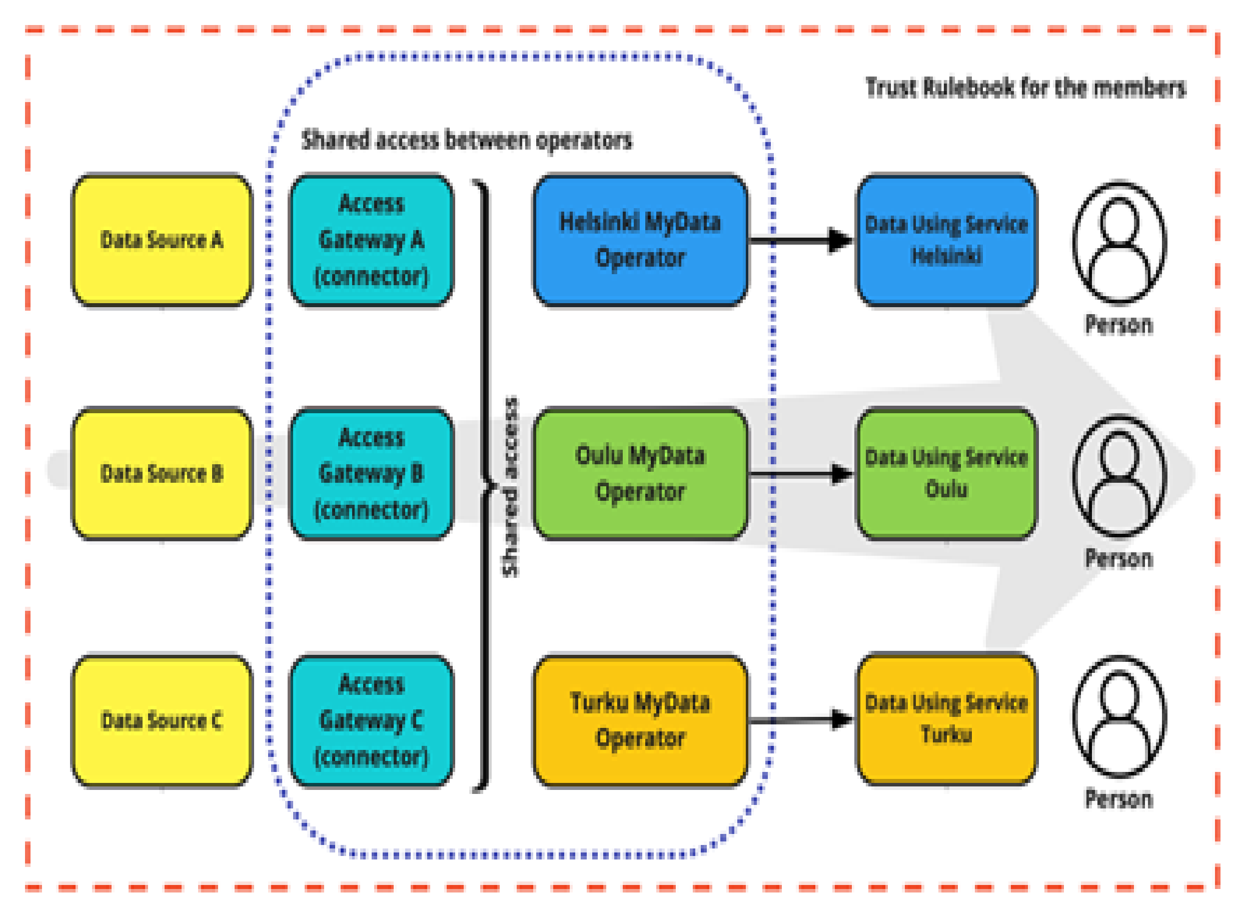
Interoperability Mechanism - details

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 Intermediary 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.



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MIM7: Spaces – the issue

MIMs 1 & 2 and MIM7 need to work well together because a key aspect of context information relates to geospatial information. Because of this MIM7 was developed to help align geospatial standards with MIM1 and MIM2. Specifically, the text of MIM7 part 1 states:

“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.”

However, the revised format of MIM1 has enabled the mapping of how a geospatial approach, based on standards from the Open Geospatial Consortium, can address context information, so this precise objective is no longer relevant for MIM7.

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MIM7 the suggested way forward

The rationale provided for MIM7 part 1 does not actually refer to NGSI-LD, nor to ETSI standards. Rather it points to the challenge for municipalities of integrating and transferring data between internal and external IT systems.

Therefore, MIM7 part 1 continues to have value, independent of the need to align with MIM1.

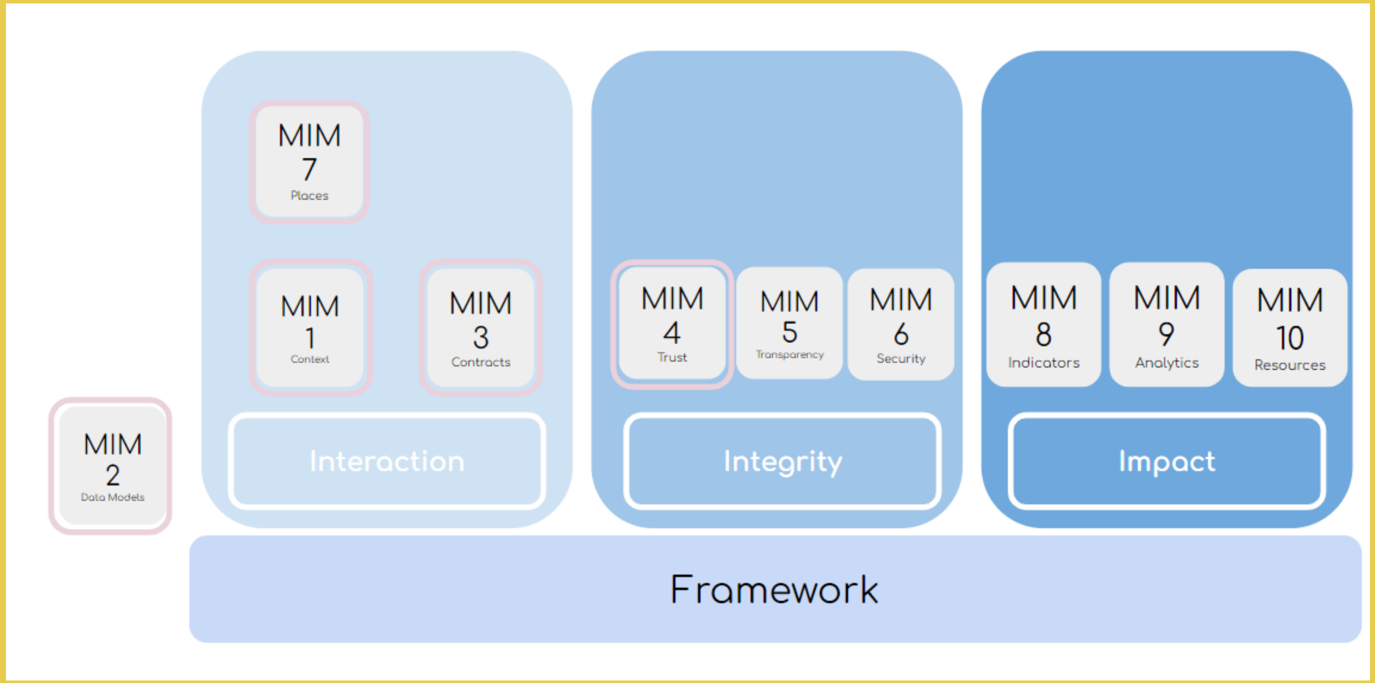
The suggestion is to change the Objective of MIM7 part 1 to:

“To enable cities to easily integrate and transfer geospatial related data between internal and external (IoT related) IT systems.”

And then rework MIM7 part 1 and fit it into the new structure.

MIMs Framework

In order to position MIMs next to each other, and to provide a rationale for adding, removing or merging MIMs, work has been done to define a MIM Framework. First, a mapping has been done to align the different MIMs on the European Interoperability Reference Architecture (EIRA). Second, a high-level easy to understand representation of this has been created:



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Questions? Comments?