FIWARE: Making Data Spaces Happen!

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FIWARE Foundation

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Open APIs
for Open
Minds

FIWARE

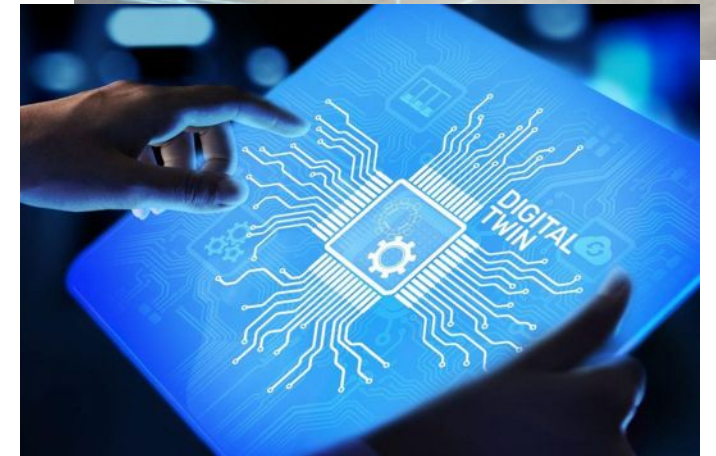# General overview

FIWARE

FIWARE provides the basis for development of smart solutions, systems integration and data spaces in multiple sectors
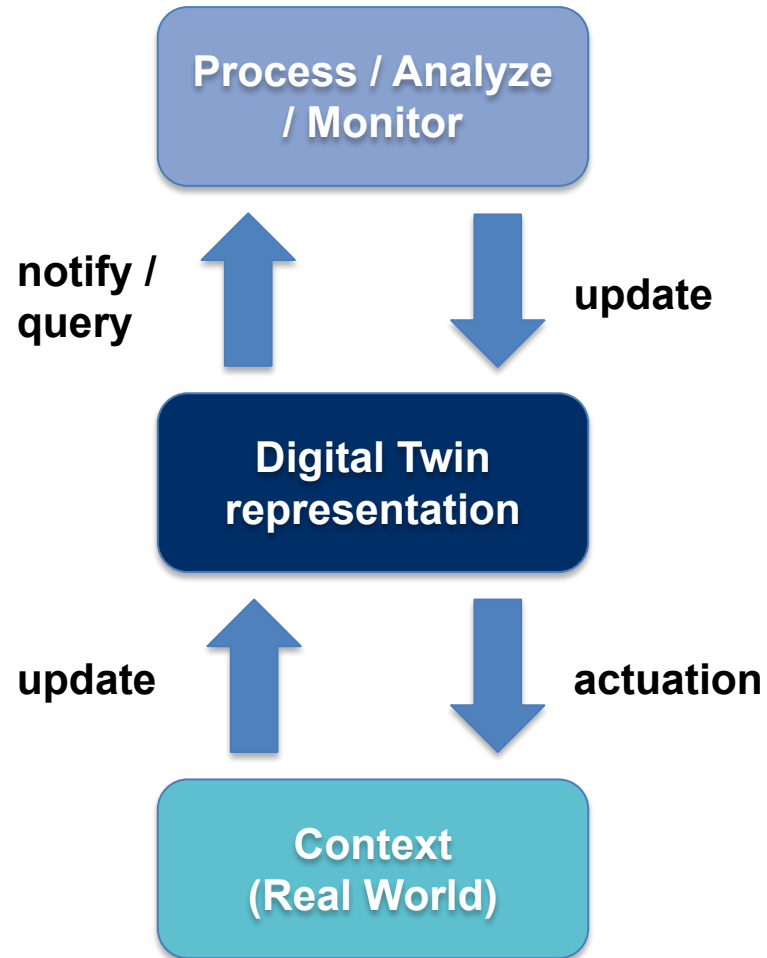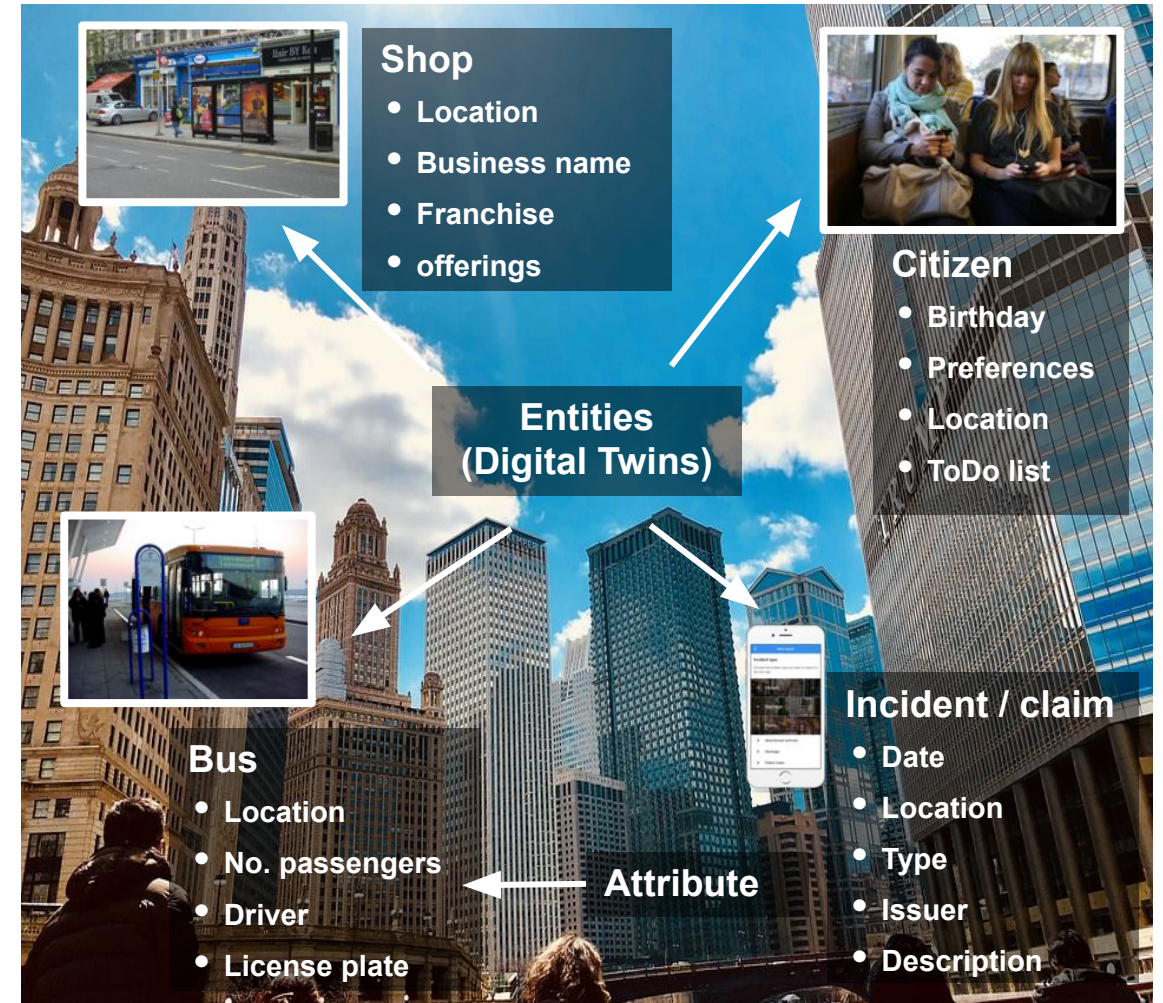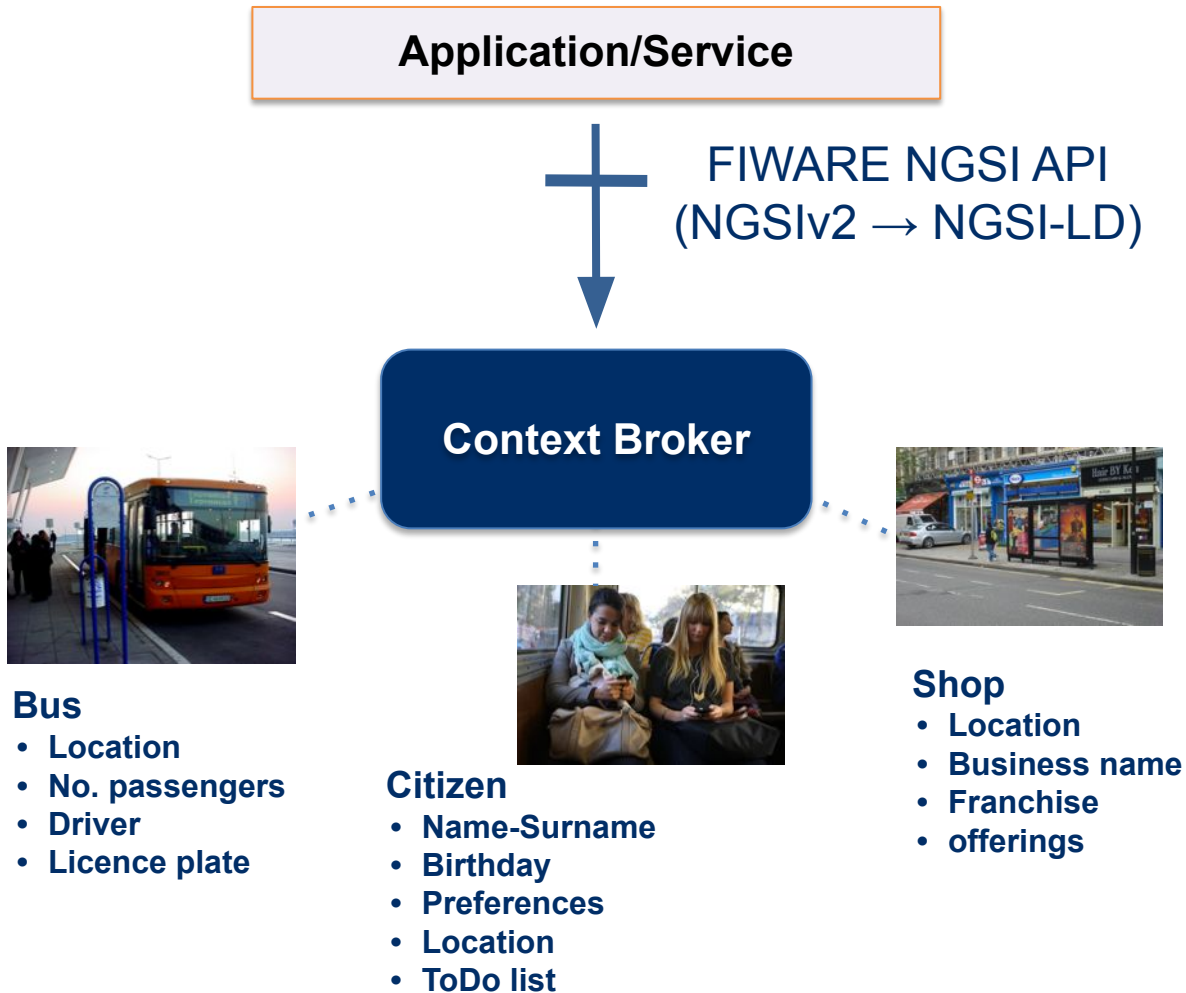

- Systems "powered by FIWARE" gather data from different sources to build a "**digital twin representation**" of the real world (also referred as "context representation") which is constantly analyzed and processed in order to automate processes or bring support to smart decisions

- Creating a **digital twin representation** of the real world helps to address:
  - How the architecture of smart vertical solutions (e.g., waste management for cities) is architected
  - How systems within an organization (e.g., a city, a farm) can be integrated breaking the information silos
  - How systems from different organizations may exchange information within data spaces they build

FIWARE

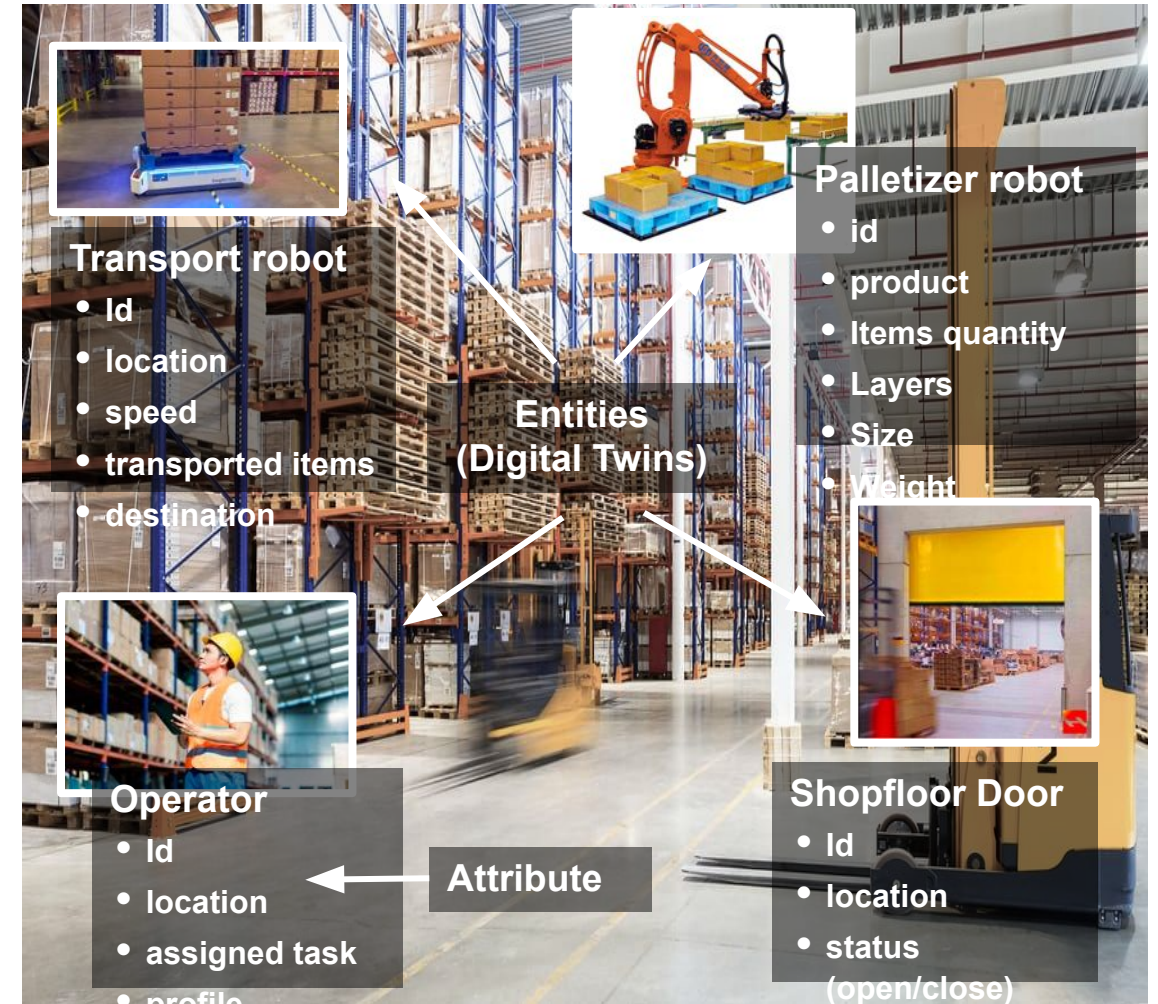# What are we referring to as Digital Twin?

- **Digital Twin** = Digital "replica" of an asset
  - Characterized by attributes
    - Properties
    - Relationships ☐ Linked Data
  - Values of attributes may change over time (or not)
  - Typically have a location (but it is not a must requirement)

- (digital representation of) **Context** = Digital Twins Collection

- **Cornerstone for the development** of interoperable and replicable (portable) Smart Solutions:
  - **Standard API** for getting access to Digital Twin data (context)
  - **Common Data Models** associated to Digital Twin classes

- **FIWARE** has driven standardization+adoption:
  - **NGSI: NGSIv2 → ETSI NGSI-LD API**
  - **Smart Data Models initiative** (500+ data models)

FIWARE

Data Exchange API: ETSI NGSI-LD

Application/Service

FIWARE NGSI API
(NGSIv2 → NGSI-LD)

Context Broker

Bus
- **Location**
- **No. passengers**
- **Driver**
- **Licence plate**

Citizen
- **Name-Surname**
- **Birthday**
- **Preferences**
- **Location**
- **ToDo list**

Shop
- **Location**
- **Business name**
- **Franchise**
- **offerings**

Shop
- **Location**
- **Business name**
- **Franchise**
- **offerings**

Citizen
- **Birthday**
- **Preferences**
- **Location**
- **ToDo list**

Entities (Digital Twins)

Bus
- **Location**
- **No. passengers**
- **Driver**
- **License plate**

Attribute

Incident / claim
- **Date**
- **Location**
- **Type**
- **Issuer**
- **Description**

FIWARE

Data Exchange API: ETSI NGSI-LD

Application/Service

FIWARE NGSI API
(NGSIv2 → NGSI-LD)

Context Broker

Transport robot
- Id
- location
- speed
- transported items
- destination

Operator
- Id
- Location
- Assigned task
- Profile

Palletizer robot
- Id
- product
- Items quantity
- La<yers
- Size
- weight

Transport robot
- Id
- location
- speed
- transported items
- destination

Palletizer robot
- id
- product
- Items quantity
- Layers
- Size
- Weight

Entities
(Digital Twins)

Operator
- Id
- location
- assigned task
- profile

Attribute

Shopfloor Door
- Id
- location
- status
(open/close)

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Data Exchange API: ETSI NGSI-LD

Application/Service

FIWARE NGSI API
(NGSIv2 → NGSI-LD)

Context Broker

Tractor
- Location
- Speed
- Planed route

Crop
- Humidity
- Leaf area
- Age

Drone
- Location
- Battery level
- Speed
- Planed route

Crop
- Humidity
- Leaf area
- Age

Drone
- Location
- Battery level
- Speed
- Planed route

Entities
(Digital Twins)

Tractor
- Location
- Speed
- Planed route

Attribute

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Data Exchange API: ETSI NGSI-LD

Application/Service

FIWARE NGSI API
(NGSIv2 → NGSI-LD)

Context Broker

Ambulance
- license plate
- location
- speed
- equipment
- current alert

Alert
- alert id
- emergency level
- description
- location
- patient id

Surgery Room
- id
- hospital
- equipment
- surgery plan

Surgery Room
- id
- hospital
- equipment
- surgery plan

Patient
- id
- location
- patient record
- treatment

Doctor
- id
- specialties
- location
- visits plan

Entities (Digital Twins)

Hospital
- name
- address
- total patient rooms
- occupied patient rooms

Attribute

Ambulance
- License plate
- location
- speed
- equipment

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Data Exchange API: ETSI NGSI-LD

Application/Service

FIWARE NGSI API
(NGSIv2 → NGSI-LD)

Context Broker

Wind Turbine
• location
• power
• wind speed
• pitch angle

Wind Plant
• Location
• Active Power
• Reactive Power
• Frequency

Smart Home
• location
• address
• installed PV
• energy consumption

Energy Storage
• active power
• reactive power
• SoC
• SoH

Wind Turbine
• location
• power
• wind speed
• pitch angle

**Entities
(Digital Twins)**

Substation
• Hi voltage
• Lo voltage
• nominal power
• power flow

Attribute

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Data Spaces: the next natural step in digitalization following a Digital Twin based system of systems approach

Architecting Smart Solutions

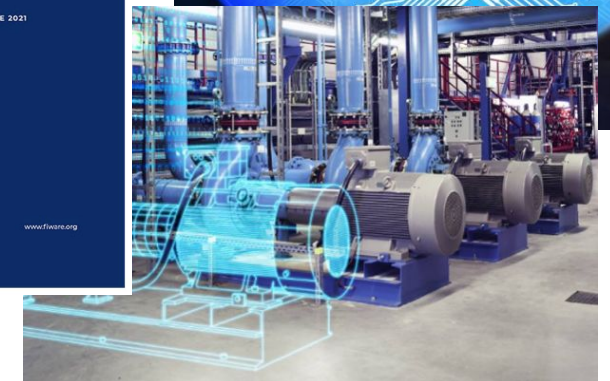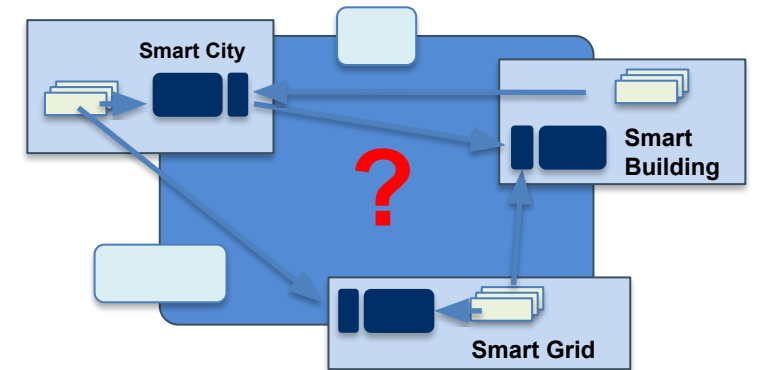**Integrating systems and sharing data within organizations**

Integrating systems and sharing data across organizations (data spaces)
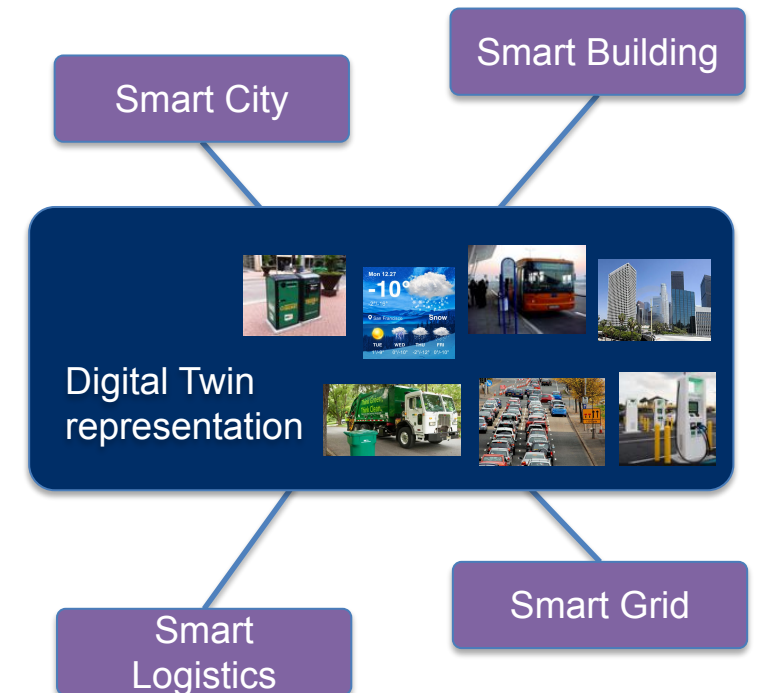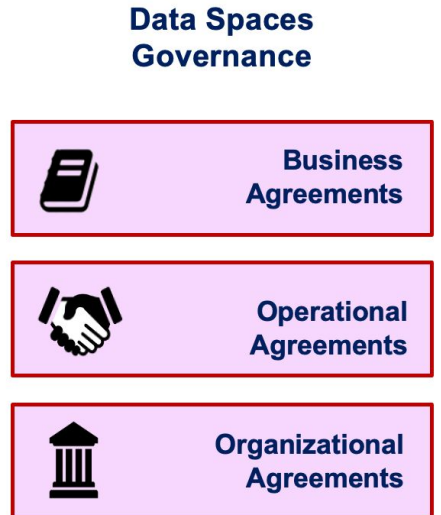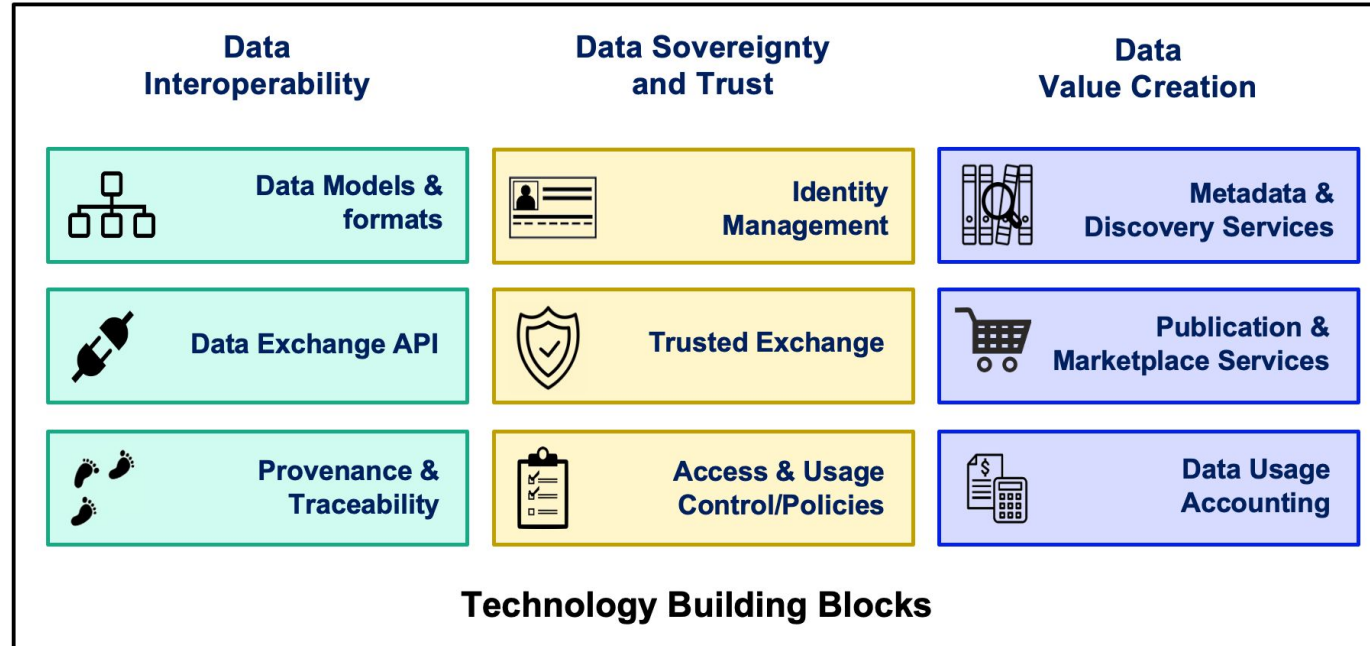
Fundamental principles in Data Spaces

- Fundamental principle in Data Spaces for a Data Economy:
  - Data providers publish data resources knowing that consumers, which are unknown "a priori", will know how to consume them
  - Data consumers know how to consume data resources published by data providers they can discover

- This requires all participants to speak the same "language":
  - Data exchange API: the sentences you construct
  - Standard data models: what you speak about (vocabulary)

- And that they can exchange in a trustful and secure manner:
  - Trust Anchor Services: how to verify when a) a participant is a valid legal entity, b) it is member of the ecosystem (therefore agrees with rules) and c) it owns the credentials it claims (they have been issued by a trusted party)
  - Common mechanisms for Identity and Access Management (IAM): how to enforce that only those owning the right credentials will be able to do access and use the data

- Besides, also fundamental:
  - Publication and Marketplace services: how to discover, contract
  - Management of provenance, traceability

Smart City

Smart Building

Smart Grid

?

FIWARE FOR DATA SPACES

POSITION PAPER / VERSION 1.0 / JUNE 2021

FIWARE
Open APIs for Open Minds   www.fiware.org

DIGITAL TWIN

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Data Spaces Building Blocks

Technology Building Blocks

Data Interoperability	Data Sovereignty and Trust	Data Value Creation	Data Spaces Governance
Data Models & formats	Identity Management	Metadata & Discovery Services	Business Agreements
Data Exchange API	Trusted Exchange	Publication & Marketplace Services	Operational Agreements
Provenance & Traceability	Access & Usage Control/Policies	Data Usage Accounting	Organizational Agreements

MATERIALIZING DATA SPACES REQUIRES TO TAKE OPTIONS AND ADOPT A MINIMUM BUT ENOUGH SET OF TECHNOLOGY STANDARDS

FIWARE helps to make things happen: transfering results of research to the market … we commit to do it for data spaces

Collaboration with iSHARE Foundation under the umbrella of i4Trust initiative

- Trust Services APIs aligned with EBSI
- Support to DID+VC/VPs + SIOPv2 and OIDC4VP

Experience implementing IDS Connector functions (TRUE Connector)

DCAT-compliant Idra component used in several market solutions

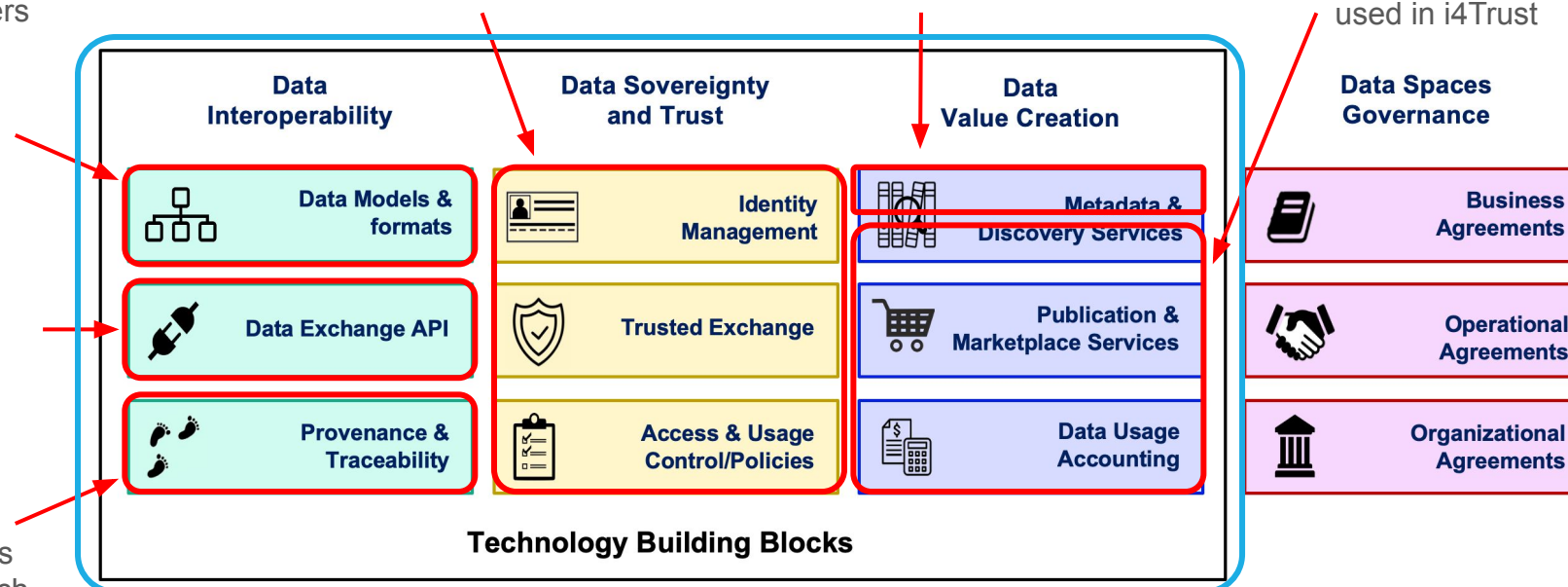Marketplace Services open source components based on industry TM Forum standards used in i4Trust

Driving fast-growing library of smart data models for developers following open agile approach

- 800+ data models,
- 14K+ terms
- 100+ contributors

Driving standardization of API for context / digital twin data exchange: ETSI NGSI-LD:

- de-facto for cities
- adopted beyond Europe

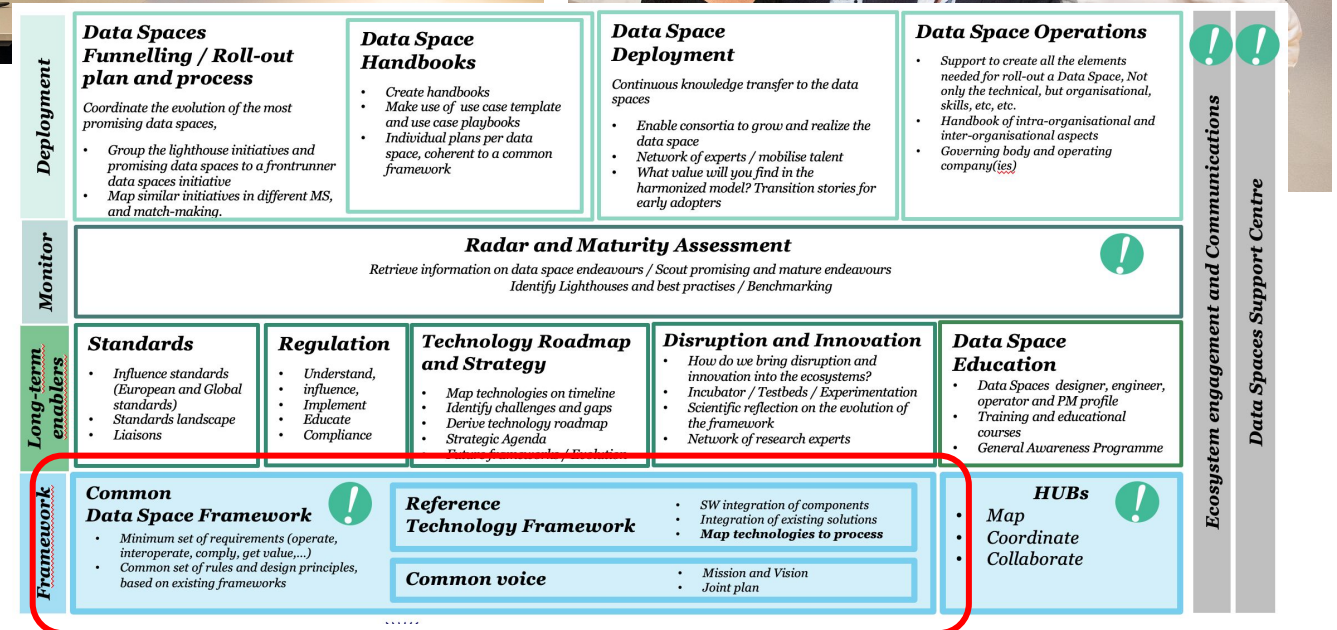Collaboration with Alastria towards EBSI-compatible no-code approach for storing logs on context / digital twin data transactions on blockchain networks

Data Interoperability
- Data Models & formats
- Data Exchange API
- Provenance & Traceability

Data Sovereignty and Trust
- Identity Management
- Trusted Exchange
- Access & Usage Control/Policies

Data Value Creation
- Metadata & Discovery Services
- Publication & Marketplace Services
- Data Usage Accounting

Data Spaces Governance
- Business Agreements
- Operational Agreements
- Organizational Agreements
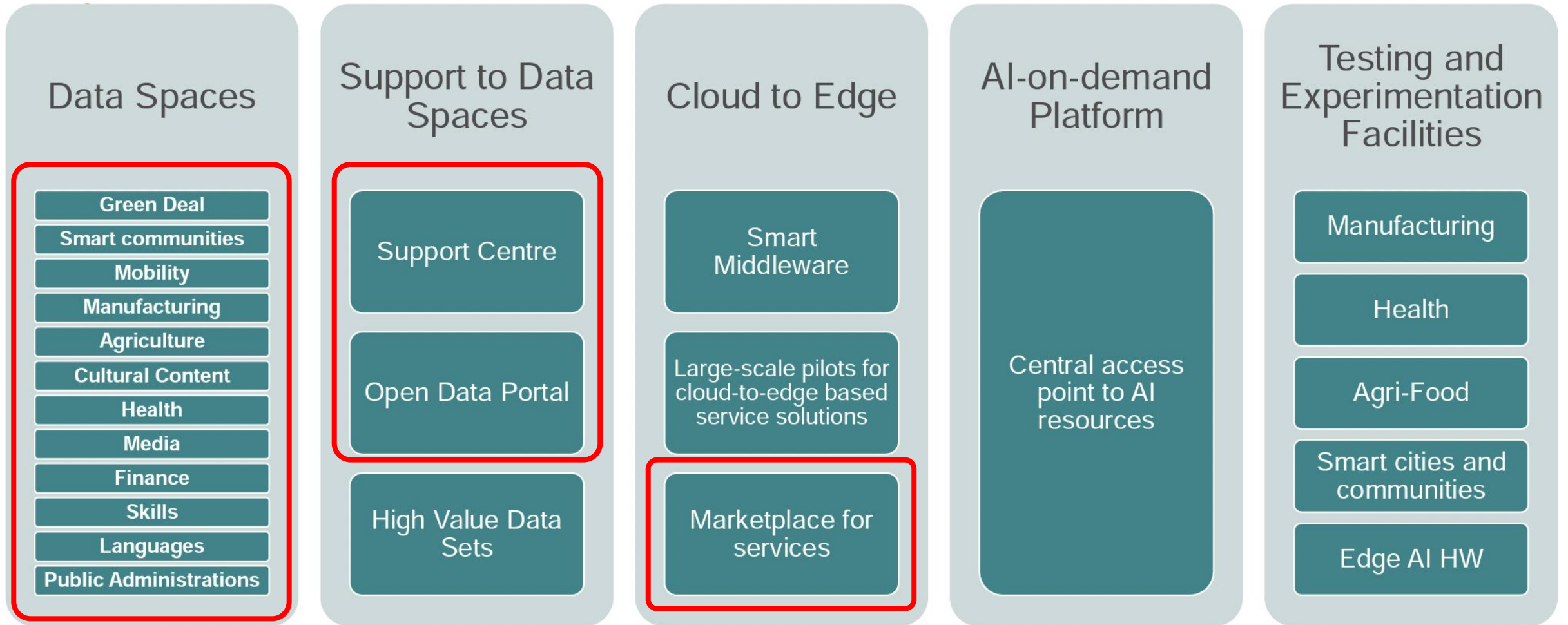
Technology Building Blocks

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Data Spaces Business Alliance: joining forces

BDVA, FIWARE, GAIA-X and IDSA launched the [Data Spaces Business Alliance (DSBA)](#) to accelerate Business Transformation in the Data Economy (Sep 23rd, 2021)

- **One voice and a common framework** to make **interoperable Data Spaces** happen;
- Together, **the Alliance's founding organisations represent 1,000+ leading key industry players**;
- With its combined **cross-industry expertise, resources and know-how**, the Alliance drives awareness and rely on **more than 100 Hubs** for dissemination
- [Technical Convergence discussions](#) towards common reference technology framework for creation of Data Spaces:
  - NGSI-LD + Smart Data Models for Data Interoperability
  - eIDAS and EBSI compatible Trust Anchor Services
  - Decentralized IAM based on W3C DID+VC/P standards (supporting OpenID and DIDcomm protocols)
  - Data Services Marketplaces based on TMForum specs and catalogue of Gaia-X compliant self-descriptions

Data Spaces in the Digital Europe Programme

Data Spaces	Support to Data Spaces	Cloud to Edge	AI-on-demand Platform	Testing and Experimentation Facilities
Green Deal	Support Centre	Smart Middleware	Central access point to AI resources	Manufacturing
Smart communities	Open Data Portal	Large-scale pilots for cloud-to-edge based service solutions		Health
Mobility	High Value Data Sets	Marketplace for services		Agri-Food
Manufacturing				Smart cities and communities
Agriculture				Edge AI HW
Cultural Content				
Health				
Media				
Finance				
Skills				
Languages				
Public Administrations				

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DSBA Technology convergence: How to get there

- Parallel workstreams launched to address a concrete aspect in depth:
  - **Workstream 1**: Incorporation of Decentralized Identifiers (DIDs) and Verifiable Credentials / Presentations (VC/VPs) in IAM framework, Trust Anchor services aligned with Gaia-X
  - **Workstream 2**: Incorporation of IDS Connector functions and support to ODRL for access control
  - **Workstream 3**: Integration of Federated Marketplace services with Catalog and Data Exchange Services as well as Data Publication services
  - **Workstream 4**: Incorporation of IDS Connector functions for usage control

- Agile approach based on delivery of subsequent versions of a Minimum Viable Framework (MVF) specification where we do not only identify standards and target components but how to integrate them

- Once alignment within a given workstream is achieved, the description of an initial/new version of the MVF will be published

- FIWARE and iSHARE Foundations have evolved the i4Trust framework to provide an implementation that aligns with the MVF specs through its subsequent versions, other projects or initiatives can do the same

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First version of DSBA MVF

- **Data Interoperability**: NGSI-LD API and smart data models for actual data exchange will be adopted and extend the interoperability mechanisms of the IDSRAM with a special focus on the IDSInfomodel and the Vocabulary Hub

- **Data Sovereignty and Trust**:
  - An eIDAS and EBSI -compatible Trust Anchor framework
  - A decentralized Identity and Access Management IAM framework based on:
    - A set of Verifiable Credential issuing protocols, e.g.: Self-Issued OpenID Provider v2 (SIOPv2), DIDComm channel, …
    - A set of verifiable presentation protocols, e.g.: OpenID Connect for Verifiable Presentations (OIDC4VP), Verifiable Presentation Request (https://w3c-ccg.github.io/vp-request-spec/)
    - An ABAC (Attribute Based Access Control) framework comprising components implementing PEP, PDP, PAP/PMP, and PIP functions

- **Data value creation**: Centralized Service Catalogue and Marketplace functions based on TM Forum recommendations, compatible with Gaia-X Catalogue of self-descriptions

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From vision to execution: i4Trust

- Software that works NOW, aligned with first results of the DSBA Technology Convergence Task Force (first Minimum Viable Framework available):

  - Compatible with iSHARE and any other Trust Anchor Services implementing DSBA specs (compatible with EBSI)
  - Open source components available on GitHub, integrated as part of the FIWARE Catalogue, data spaces participants can deploy and operate
  - Training material (tutorials, training)

- A framework curated through its use in selected pioneer experiments:

  - 13 experiments completed in Dec 2022 helped to curate the framework
  - 17 experiments started Jan 2023 (see press release)
  - Multiple application domains: cities, tourism, mobility, agriculture, logistics, …
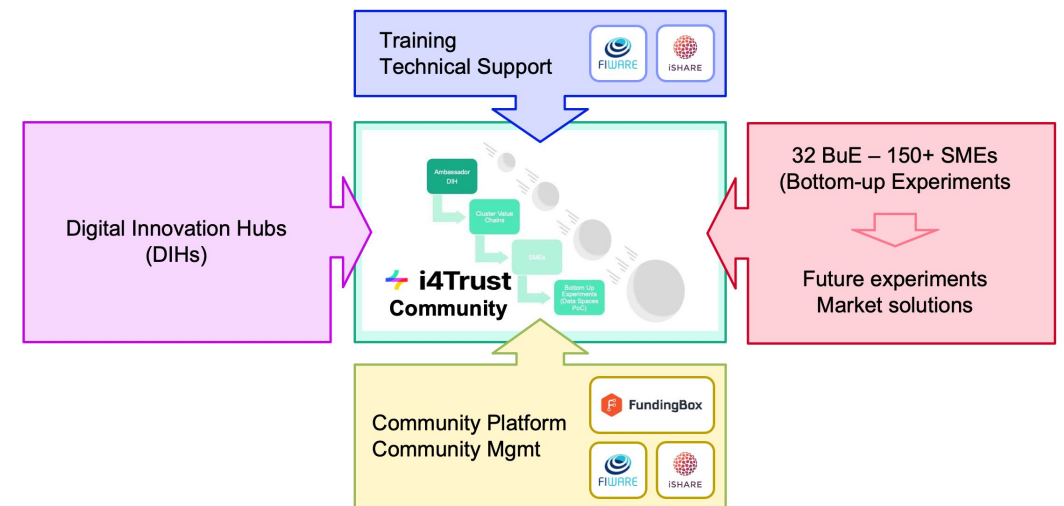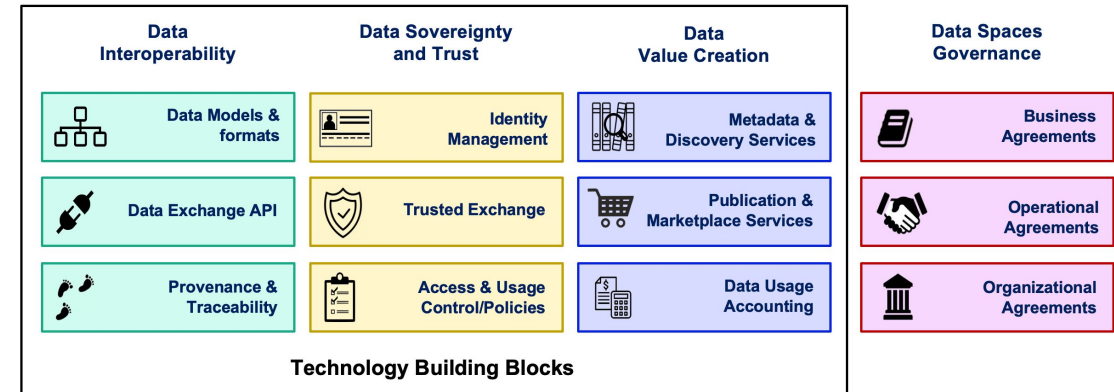
Getting a bit deeper

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Data Spaces: next natural step in digital transformation of cities

- Currently, using NGSI-LD and common data models:
  - cities are able to break information silos and integrate existing smart vertical applications following a system of systems approach
  - providers benefit from developing smart applications once and be able to replicate them across multiple cities
  - cities benefit from the ability to replace smart applications since they offer equivalent interfaces, thus avoiding vendor lock-in

FIWARE
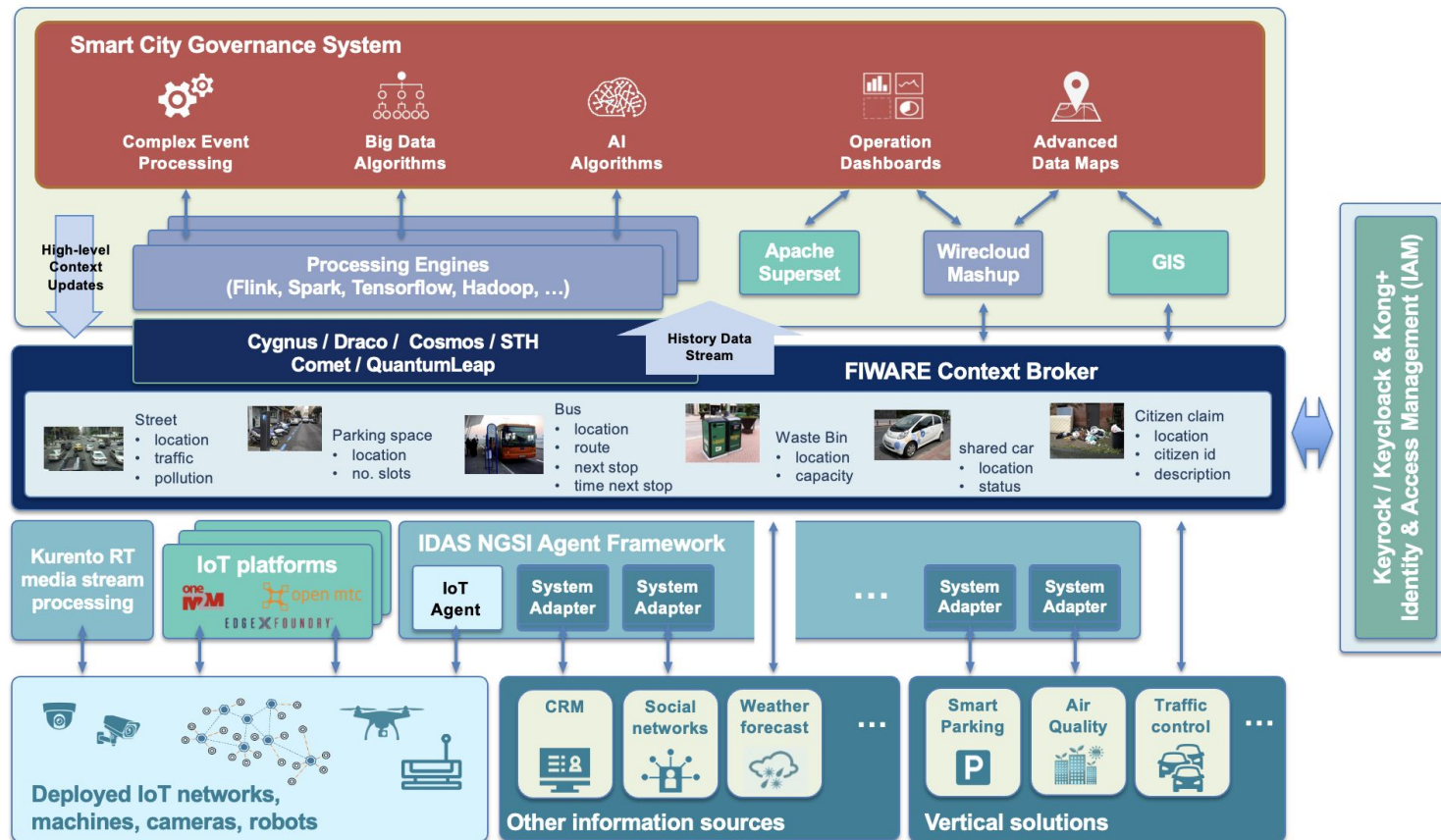
Data Spaces: next natural step in digital transformation of cities

- The next natural step for cities is to integrate new verticals available from the cloud, expanding their system of systems architecture.

- However, this requires that:
  - each vertical application comes with access control policies based on credentials that cities can assign to their users without them being obligued to be registered in any IAM (Identity and Access Management) system linked to the application provider
  - vertical application providers can monetize usage of their data services by cities

- DID and VC/VP and SIOPv2+OIDC4VP provide the means for that
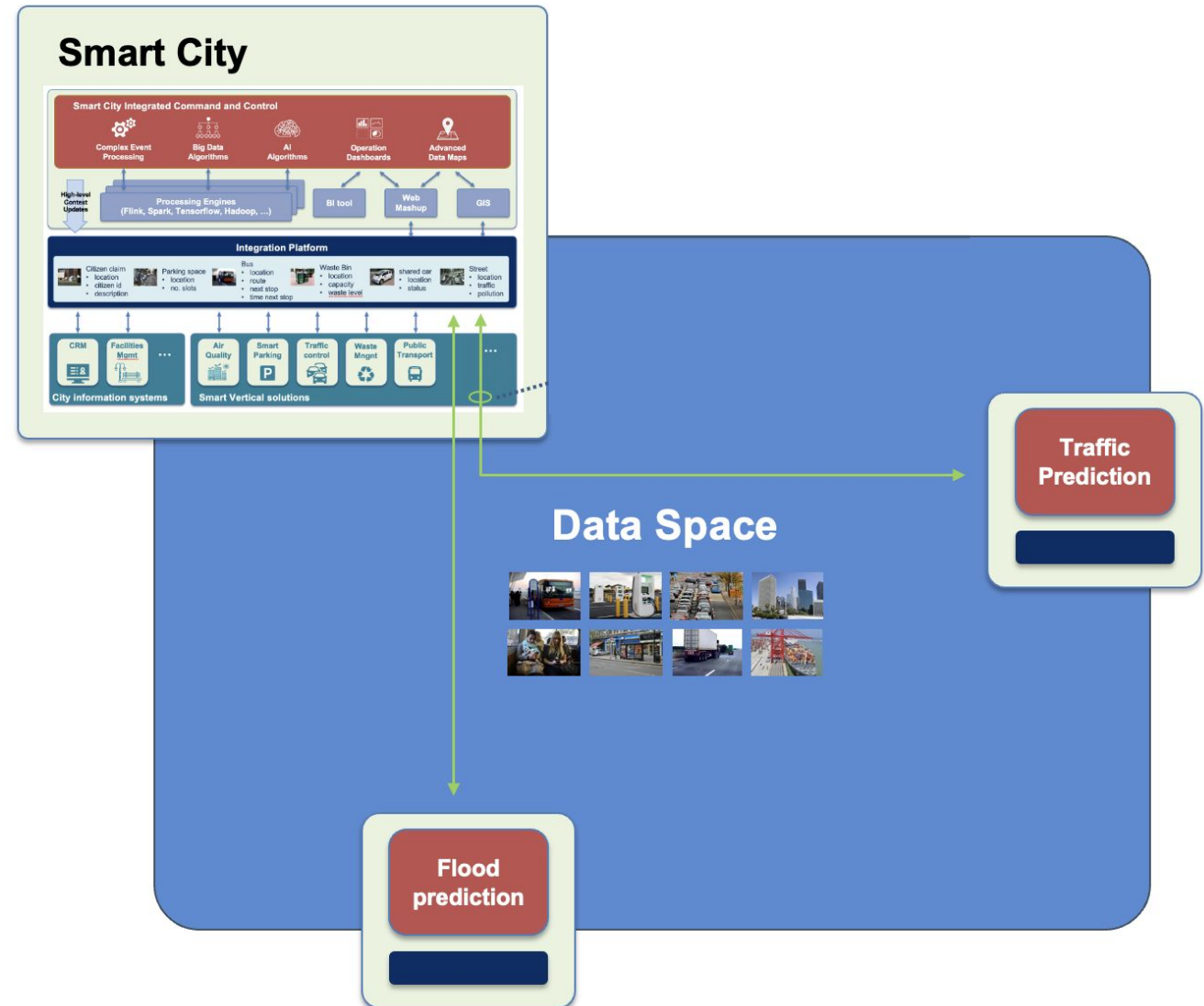
Data Spaces: next natural step in digital transformation of cities

- This paves the way for Data Spaces formed by:
  - cities using data application services offered by third parties
  - service providers offering services to cities

- … and where even cities can offer data services to other organizations from different domains (logistic operators, ports, buildings, …)
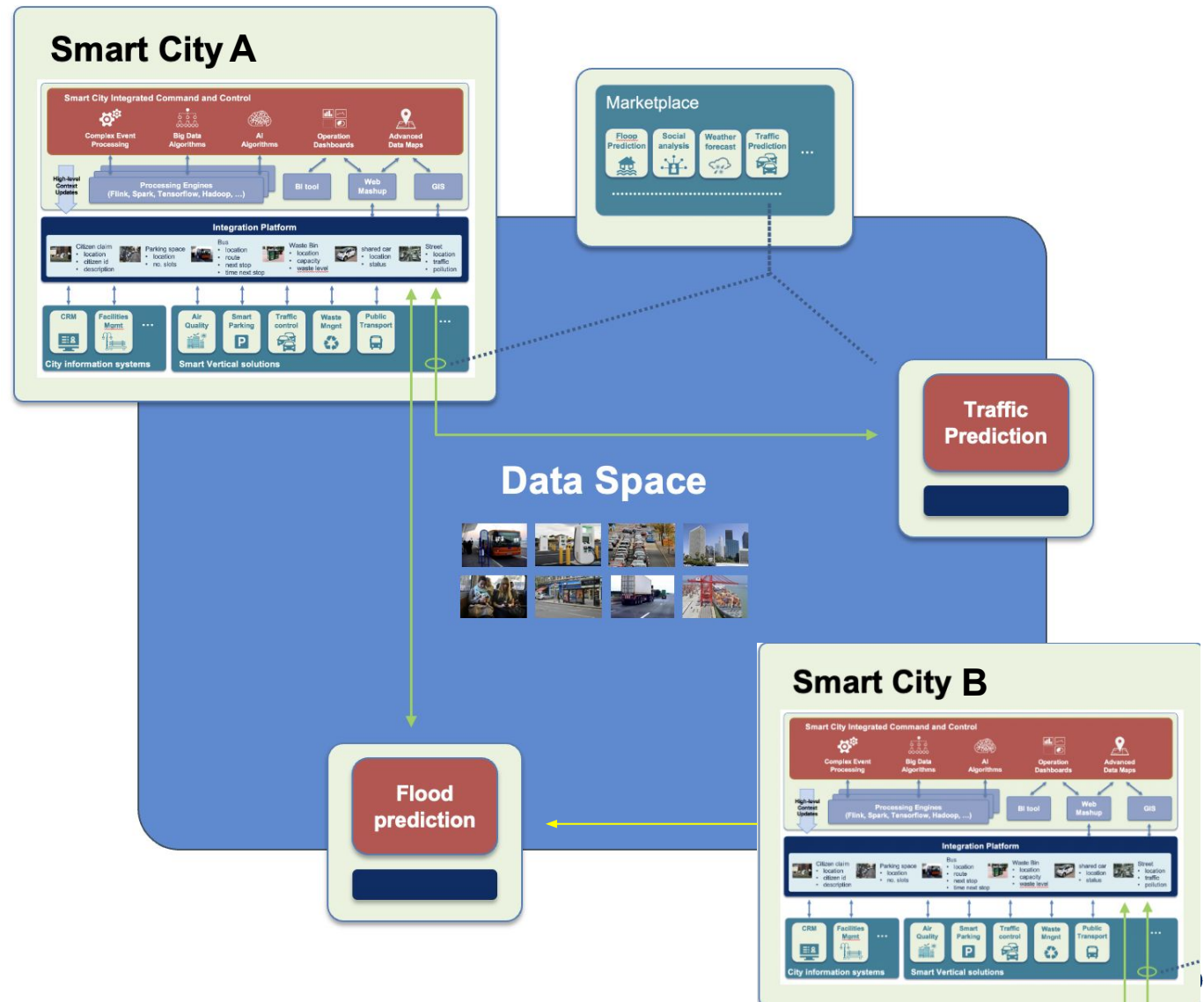
Description of data services

- VCs associated to standard Gaia-X attributes described in the Trust Framework

- VCs issued by certification agencies, for example describing compliance with certain regulations/recommendations. Examples:
  - GDPR compliance
  - Low carbon emission
  - …

- VCs issued by certification agencies describing compliance with certain standards. Examples:
  - NGSI-LD API supported
  - Data models X, Y, Z supported
  - IDS Connector used
  - …

- VC describing everything that is needed to support Attribute Based Access Control (ABAC) by the service provider:
  - claims that are meaningful to assign to service users
  - policies associated to combination of claims and other potential environment attributes
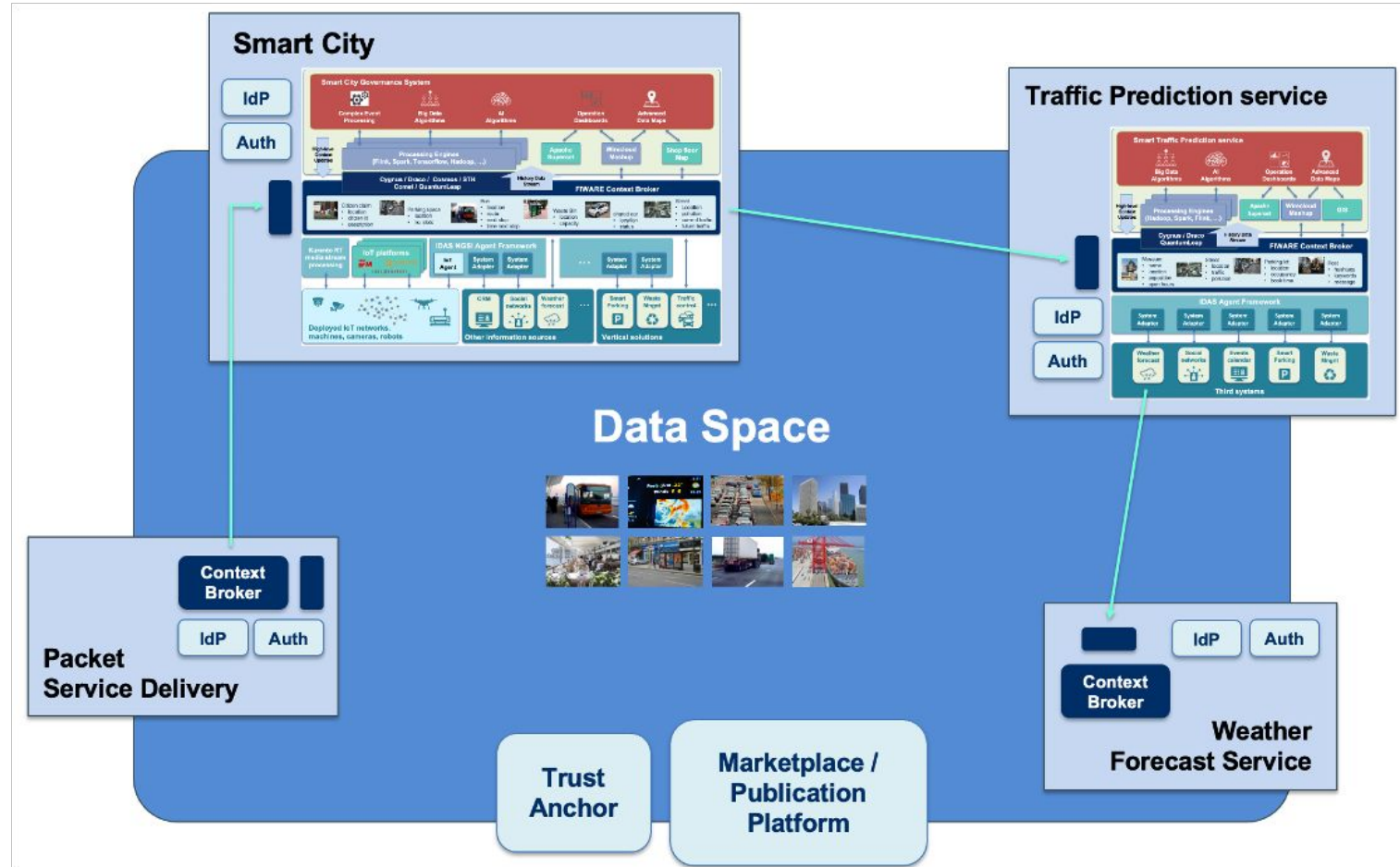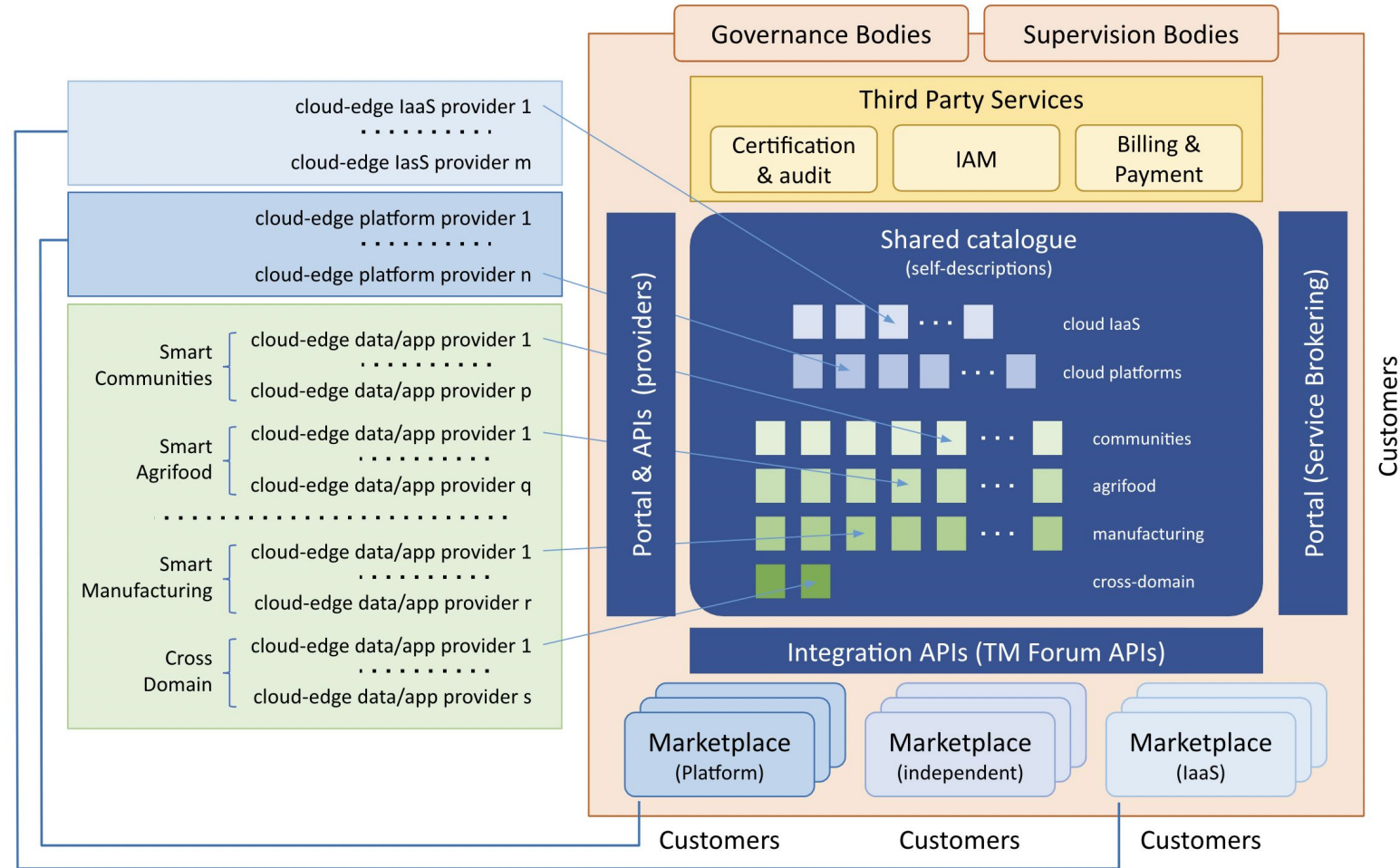
Multi-level Access Control

- Organizations that acquire rights to use a data service:
  - become trusted issuers of VC including claims relevant for data service access
  - They can issue such VCs for users within the organization
- Access Control is then performed at several levels:
  - Verifying whether participants can be trusted (Trust Anchor service)
  - Verifying credentials at platform/connection level (e.g. NGSI-LD or IDS connector support)
  - Verifying whether access rights were properly acquired (e.g., via some marketplace)
  - Verifying that credentials at app level allow to perform the requested operation
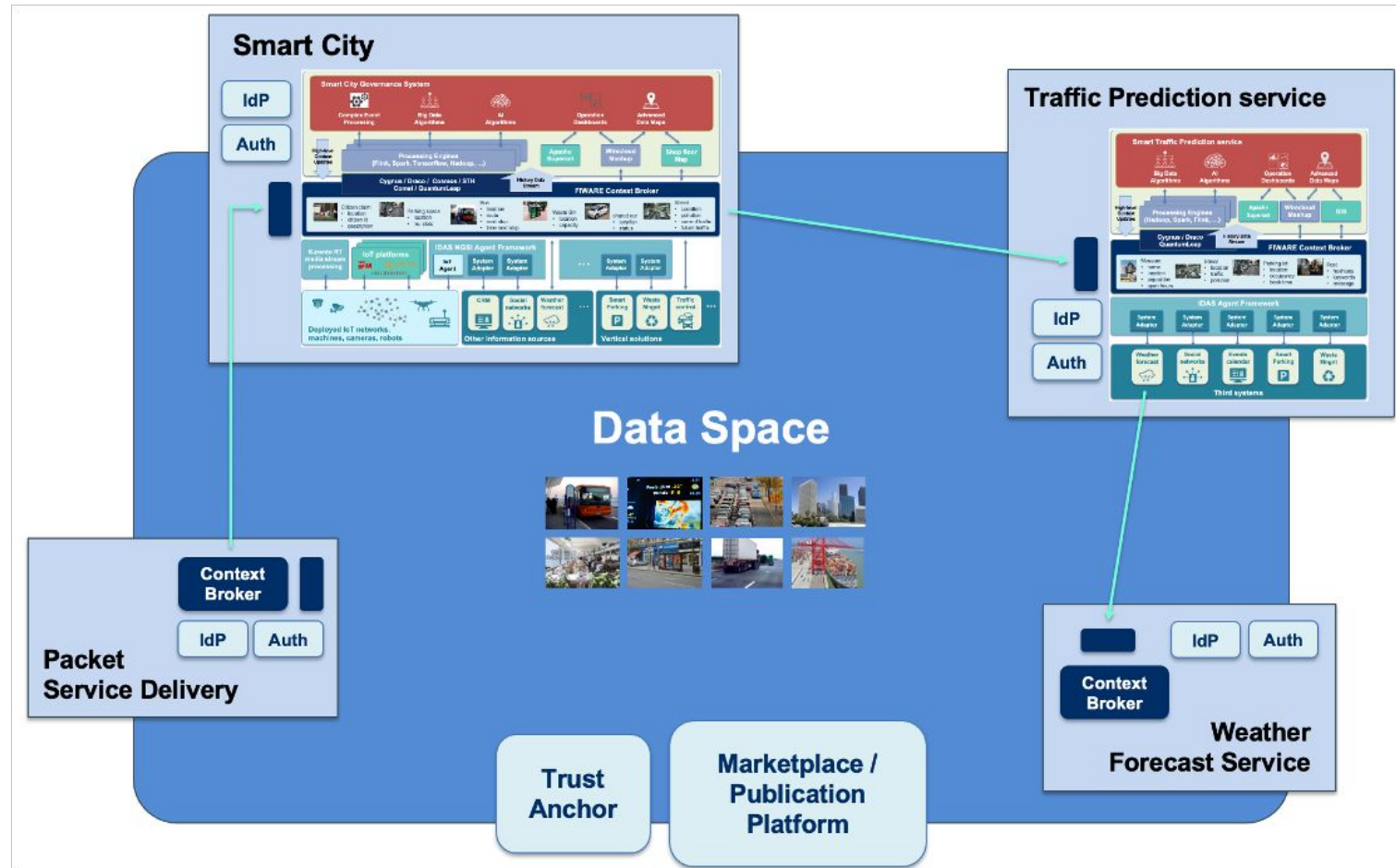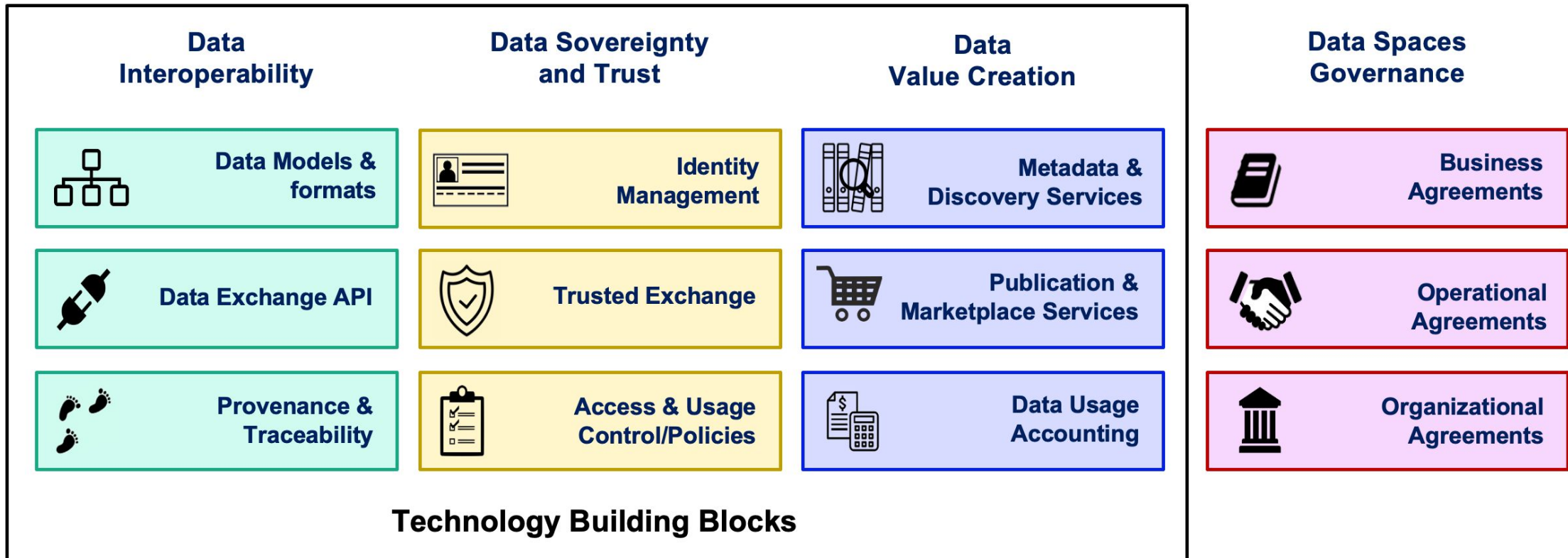
Marketplace and Service Catalogue integration

- Different kind of service providers:
  - IaaS providers
  - Platform service providers
  - Data/App service providers
- Access rights acquired via federated marketplaces relying on a Shared Catalogue of service & service offering descriptions:
  - formatted as Verifiable Credentials / Presentations (VC/VP) in compliance with Gaia-X specs
  - Shared Catalogue relying on electronic ledgers to allow decentralized storage and facilitate spreading of info to federated marketplaces
- Standard TM Forum APIs used:
  - by federated marketplaces to access service & service offering descriptions
  - to record logs during lifecycle of service orders and activation of services
 - to record logs during execution of services

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Summary

Data Spaces building blocks

Data Interoperability	Data Sovereignty and Trust	Data Value Creation	Data Spaces Governance
Data Models & formats	Identity Management	Metadata & Discovery Services	Business Agreements
Data Exchange API	Trusted Exchange	Publication & Marketplace Services	Operational Agreements
Provenance & Traceability	Access & Usage Control/Policies	Data Usage Accounting	Organizational Agreements

Technology Building Blocks

FIWARE

Data interoperability

- Building Blocks (starting baselines):
  - Data exchange API: ETSI NGSI-LD API
  - Data Models: Smart Data Models initiative

- Foreseen activities:
  - Evolution of NGSI-LD specifications within ETSI
  - Support to stream-based linked data exchange (LDES)
  - Definition of models following implementation-driven approach and contribution to Smart Data Models initiative
  - Tools and components for measuring/improving data quality
  - Components for managing traceability and provenance of data
  - Inventory of open source products compliant with reference specs

- Collaboration with relevant projects/initiatives:
  - Data Spaces Support Center (Digital Europe Programme)
  - Data Spaces Business Alliance (DSBA) and associations
  - EBSI (European Blockchain Service Infrastructure)
 - Living-in.EU / OASC (evolution of MIM-1, MIM-2)
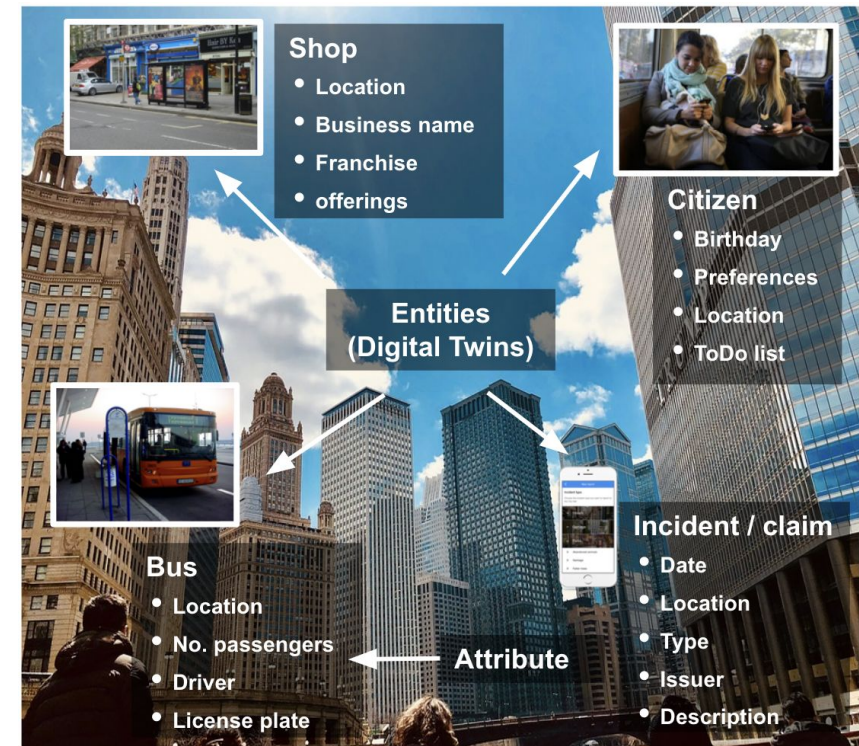
Data sovereignty and trust

- Building Blocks (starting baselines):
  - Trust Anchor Framework compatible with [EU DI Wallet](#) and [EBSI](#):
    - Mechanism for verifying legal identity
    - Mechanism for verifying compliance with data space participation rules
    - Mechanism for verifying trustworthiness of credential issuers
  - Decentralized Identity and Access Management (IAM):
    - Verifiable Credentials Issuance Protocols: [SIOPv2](#)
    - Verifiable Credentials Exchange Protocols: [OIDC4VP](#)
    - ABAC (Attribute Based Access Control) framework

- Foreseen activities :
  - Follow up technical convergence activities within DSBA
  - Inventory of open source products compliant with reference specs

- Collaboration with relevant projects/initiatives:
  - [Data Spaces Support Center](#) / DOME (Digital Europe Programme)
  - [Data Spaces Business Alliance (DSBA)](#) and associations
  - [EBSI (European Blockchain Service Infrastructure)](#)
  - [Living-in.EU](#) / [OASC](#) (creation of new MIM)

Data value creation

- Building Blocks (starting baselines):
  - Service Self-descriptions: [Gaia-X specifications](#)
  - Data Publication functions: [DCAT](#), [DCAT-AP](#)
  - Data Services Marketplace functions: [TM Forum APIs](#)

- Foreseen activities:
  - Follow up technical convergence activities within DSBA
  - Follow up evolution of DCAT/DCAT-AP and TM Forum specs
  - Integration of Data Publication and Data Service Marketplaces
  - Analysis of frameworks for metadata annotation and discovery
  - Inventory of open source products compliant with reference specs

- Collaboration with relevant projects/initiatives:
  - [Data Spaces Support Center](#) / DOME (Digital Europe Programme)
  - [Data Spaces Business Alliance (DSBA)](#) and associations
  - [TM Forum](#)
  - [Living-in.EU](#) / [OASC](#) (evolution of MIM-3)
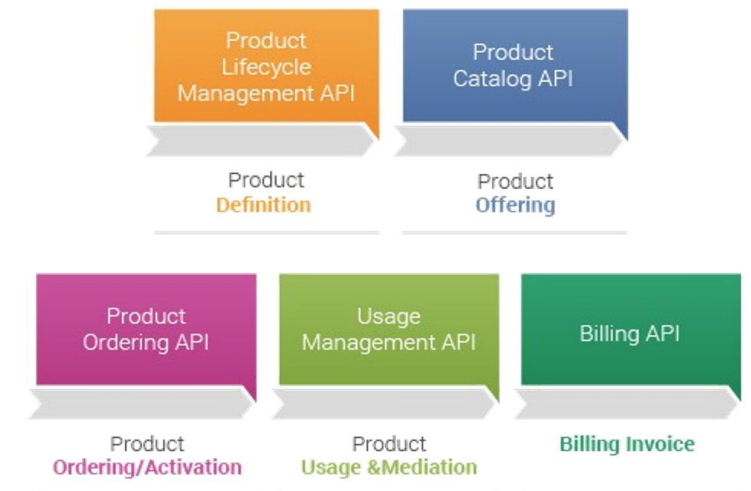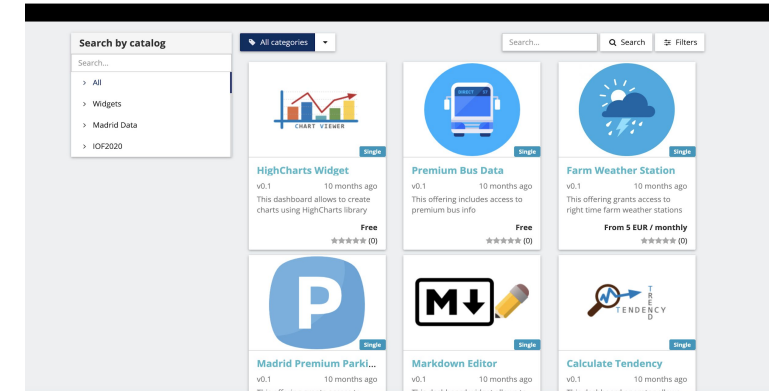
Summary

- Vision and design principles are important but we need to perform a successful transfer to the market … starting now!

- FIWARE has a good track record in moving from vision to execution, making things happen!

- We shall not re-invent the wheel: leverage relevant open standards, open source frameworks

- DSBA represents the opportunity to join forces: BDVA, FIWARE, Gaia-X, IDSA … together !!

- i4Trust is enabling data spaces now and emerges as first Minimum Viable Framework aligned with first results of the DSBA Technology Convergence work

FIWARE

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http://fiware.org
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