INSPIRE - Gaia-X Use-cases

Final Report

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1 Contents

2 Introduction

Gaia-X defines a broad and complex ecosystem, but Gaia-X is also still a work-in-progress. What Gaia-X is, and how it may be of interest for INSPIRE is not directly obvious. This document starts in Chapter 3 with an introduction to Gaia-X: what it is, how it is expected to work and how all participants, services and data is described in a semantic way by Self-Descriptions. The following chapter 4 explores how different parts of Gaia-X may be of interest for INSPIRE. The goals of INSPIRE are focussed on the exchange of (location based) data. As such, not all aspects of Gaia-X are of interest to INSPIRE. To further explore how Gaia-X may benefit INSPIRE, several use-cases are explored in chapter 5. The use-cases are partly taken from the projects API4INSPIRE[1] and GeoE3[2]. The latter defines a data integration platform as well for geospatial data and thus has an overlap with Gaia-X and INSPIRE. For each use-case the importance of the different aspects of Gaia-X are evaluated and the GeoE3 architecture is mapped to the Gaia-X architecture. Finally, in chapter 6 an example Self-Description (formal description of an entity, see section 3.3) for a data service is created in a step-by-step process.

3 What is Gaia-X

According to the Gaia-X website (https://gaia-x.eu/what-is-gaia-x/):

> *It is a federated and secure data infrastructure, whereby data are shared openly, with users retaining control over their data. It links many cloud service providers in a wider, transparent and open ecosystem to drive the European Data economy of tomorrow.*

Gaia-X allows participants to describe themselves and the resources they have to offer and allows participants to find the resources they are looking for. These resources can be hardware, like CPU nodes, disk space or network infrastructure, they can be software services, or they can be data.

Gaia-X specifies the basic rules required for everyone to follow in order to create a basis of trust. On top of these basic rules, ecosystems can add additional requirements in order to improve the interoperability inside a given domain.

3.1 Ecosystems

An ecosystem in Gaia-X is a group of participants that jointly create a community that uses the Gaia-X architecture and conforms to the Gaia-X requirements. Such a community can use its own federation services to organise itself and can specify ontologies and vocabularies that help make the descriptions of the resources used in the ecosystem more interoperable.

Many ecosystems may exist, and an actor may join multiple ecosystems. An example of an ecosystem is Catena-X[3] in the automotive sector.

Figure 1 gives an overview of the Gaia-X ecosystem infrastructure. The main building blocks are

- Identity and Trust
- Federated Catalogue
- Sovereign Data Exchange
- Compliance

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[1] https://datacoveeu.github.io/API4INSPIRE/
[2] https://geoe3.eu/
[3] https://catena-x.net

These topics will be described in more detail in chapter 4. The following sections first take a look at the trust aspect and how it related to the Gaia-X conceptual model.

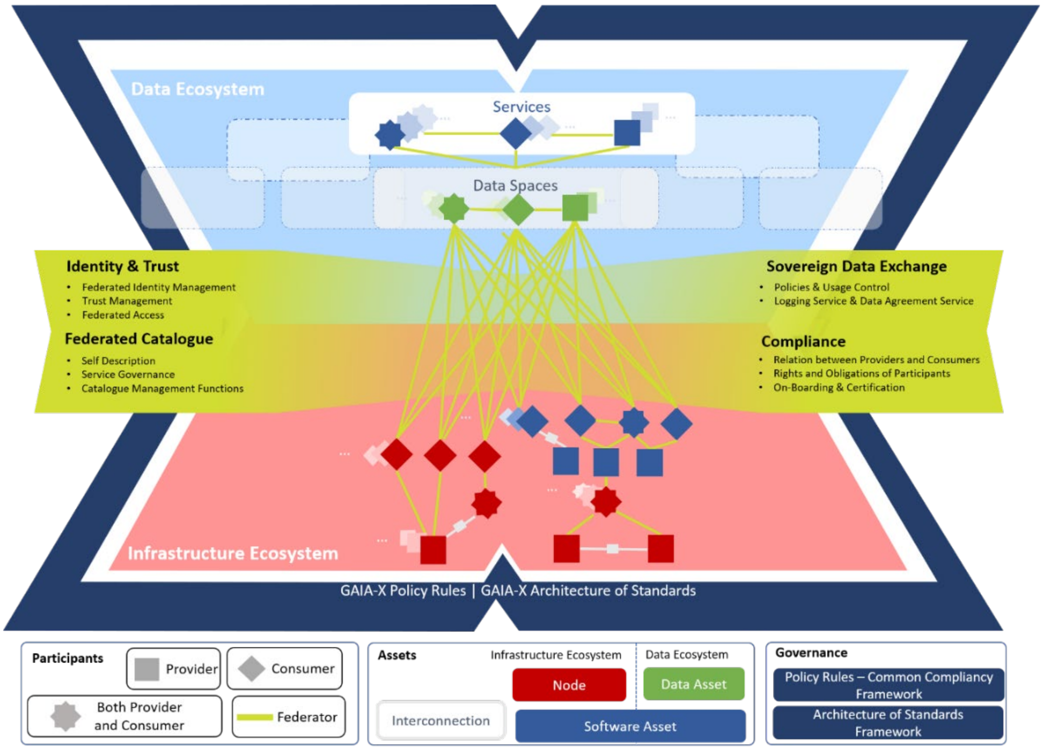

Figure 1: The Gaia-X ecosystem infrastructure[4]

3.2 Trust Framework & Ecosystems

The core of Gaia-X is trust. How can participants in an ecosystem be sure that the descriptions that other participants provide are trustworthy? Therefore, the basis of Gaia-X requires a trust framework (called the *Trust Plane*, see Figure 2) that describes how claims in Self-Descriptions are signed and how those signatures can be validated.

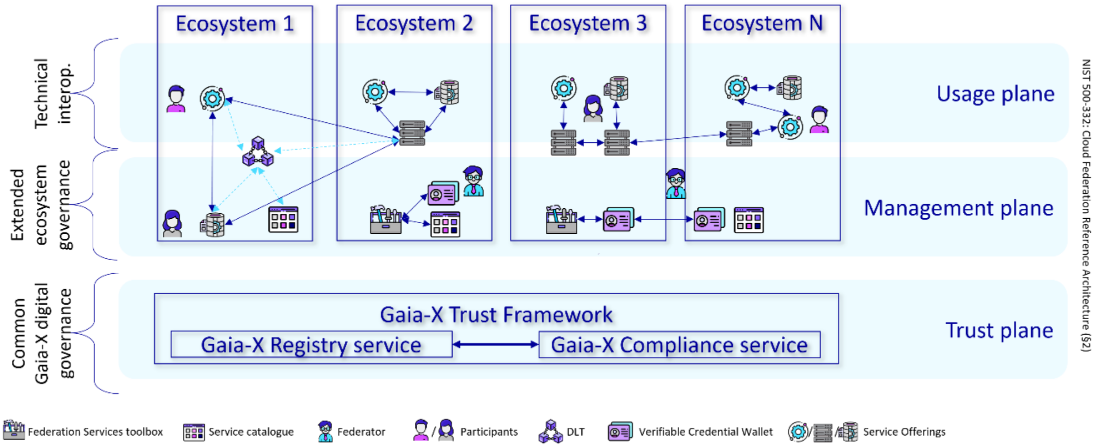

Figure 2: Cloud Federation Reference Architecture[5]

[4] https://docs.gaia-x.eu/technical-committee/architecture-document/latest/ecosystem/
[5] https://docs.gaia-x.eu/technical-committee/architecture-document/latest/ecosystem/

At the root of the chain of trust are the Trust Anchors[6] that verify identities of participants and issue cryptographic keys to these participants. An ecosystem can define additional trust anchors besides the standard Gaia-X ones.

3.3 Self-Description and Verifiable Claims

A key concept in Gaia-X is that of the Self-Description. Every actor, service or resource describes itself using a Self-Description. Self-Descriptions contain claims and labels. Claims can be signed by any other participant and thus become verifiable claims. Labels can only be signed by a Gaia-X Label Issuer operated by a Trust Anchor.

Technically, a Self-Description is a JSON-LD file following the core ontology schemas defined by Gaia-X and additional schemas defined by the ecosystem. JSON-LD is a lightweight Linked Data format. It is easy for humans to read and write. It is based on the already successful JSON format and provides a way to help JSON data interoperate at Web-scale[7].

The Self-Description is signed by the Participant that created the Self-Description. It contains claims that can be individually signed by third parties. For instance, the claim "Company X is ISO 9001 certified" could be signed by ISO so that this claim can be verified to be true.

3.4 Gaia-X Conceptual Model

The Gaia-X conceptual model[8] describes the concepts in Gaia-X and how they relate to each other. Each entity that is in the Gaia-X scope is described in a Self-Description.

The main entities in the conceptual model (see Figure 3) are:

- Participants
- End Users
- Resources
- Service Offerings
- Federation Services
- Trust Anchors

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[6] https://docs.gaia-x.eu/policy-rules-committee/trust-framework/22.04/trust_anchors/
[7] https://json-ld.org/
[8] https://docs.gaia-x.eu/technical-committee/architecture-document/latest/conceptual_model/

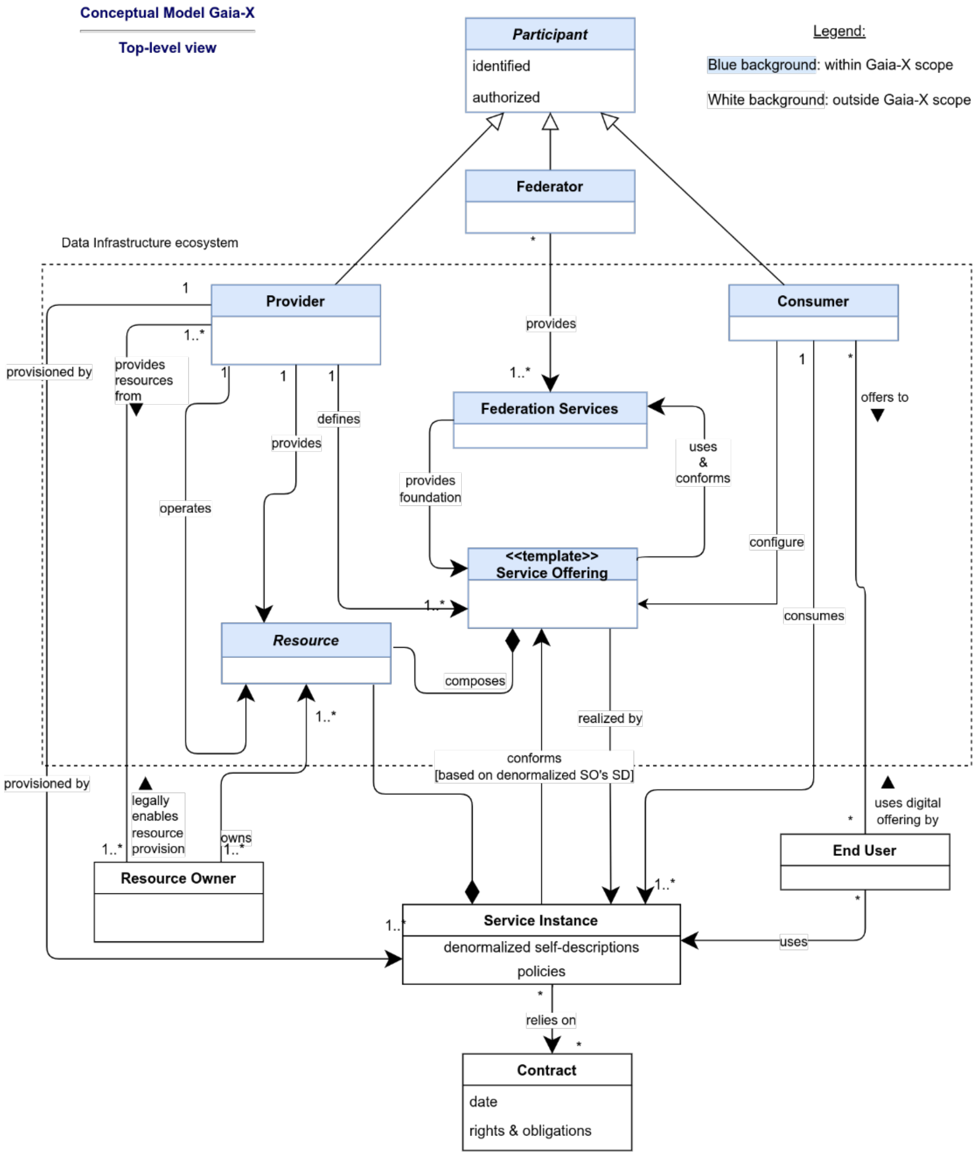


Figure 3: The Gaia-X conceptual model[9]

3.4.1 Participants

Participants are part of the Gaia-X ecosystem and have a Self-Description. There are three roles for participants, and a participant can take on multiple roles.

- **Provider:** A Provider is a Participant who provides Resources in the Gaia-X Ecosystem. The Provider defines the Service Offering including terms and conditions as well as technical Policies. Furthermore, it provides the Service Instance that includes a Self-Description and associated Policies. Therefore, the Provider operates different Resources:
    - Data
    - Service (e.g., Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg (LUBW); Bureau de Recherches Géologiques et Minières (BRGM); We-Transform INSPIRE as a service)

[9] https://docs.gaia-x.eu/technical-committee/architecture-document/latest/conceptual_model/

        - Hardware (e.g., data centers like BITBW)
    - **Consumer:** A Consumer is a Participant who searches Service Offerings and consumes Service Instances in the Gaia-X Ecosystem to enable digital offerings for End-Users:
        - Service (e.g., Can-I-Swim-App)
        - Hardware (e.g., LUBW, BRGM)
    - **Federator:** Federators coordinate the Federation Services and the Federations which are independent of each other. There can be one or more Federators per type of Federation Service (e.g., European Commission (EC) / INSPIRE).

3.4.2 End Users

End users are not part of the Gaia-X ecosystem and do not have a Self-Description. (e.g., Users of the Can-I-Swim-App)

3.4.3 Resources

Something that can be offered to consumers, such as data, hardware or services.
Resource Owners describe a natural or legal person, who holds the rights to Resources that will be provided according to Gaia-X regulations by a Provider and legally enable its provision. Resource owners are outside the Gaia-X ecosystem (e.g., LUBW, BRGM).

3.4.4 Federation Services

The federation services[10] are the distributed part of Gaia-X that allow participants to find each other and search for what other participants have to offer. The main part of the federation services is the federated catalogue. It allows participants to register their Self-Descriptions and search, using semantic technology, Self-Descriptions of other participants. The catalogue also validates Self-Descriptions according to the schemas specified in the ecosystem the catalogue is part of and verifies the keys used to sign the claims in the Self-Descriptions.
A **Service Offering** is a "package" of one or more resources being offered for use by consumers.

3.4.5 Trust Anchors (TA)

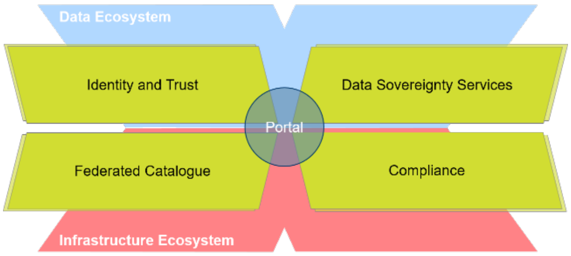
For a given ecosystem, the Trust anchors are the entities considered by all Participants to be trustworthy when establishing the chain of cryptographic certificates. Ecosystems can select their own Trust Anchors; however, cross ecosystem trust requires the selected Trust Anchors to comply at least with the same rules that the common Gaia-X ecosystem Trust Anchors shall comply with.

[10] https://docs.gaia-x.eu/technical-committee/architecture-document/latest/federation_service/

4 Parts of Gaia-X that are of interest for INSPIRE

This chapter lists the parts of Gaia-X that seem to be especially interesting for INSPIRE.

Gaia-X consists of four main building-blocks: Identity and Trust, Federated Catalogue, Compliance and Data Sovereignty Services. Each of these building-blocks has aspects that are of interest for INSPIRE.



4.1 Identity & Trust

The Identity & Trust topic deals with the identity of participants in the Gaia-X environment, and whether claims that these participants make can be trusted or not. Some typical aspects this involves are:

- Is the publisher valid? On the Internet, everyone can claim to be everyone else. Being able to verify that the party on the other side of a transaction really is who they claim to be is the first requirement for a successful transaction.
- Is a Self-Description published by the publisher? Everything in Gaia-X is described by a Self-Description, but is the party that published a certain Self-Description really the party the owns the (assets described by) the Self-Description?
- Is the Self-Description truthful? In a Self-Description a party makes claims about themselves and about their assets. Are these claims true? If a party claims to be ISO 9001 certified, is this claim signed by ISO?

The trust framework in Gaia-X is based on Trust Anchors (see previous chapter 3.4.5). In Europe the likely candidates for the role of Trust Anchor are the institutes on the eIDAS Trusted Lists[11], the EU-Published list of institutes that the EU Member States deem trustworthy in accordance with the eIDAS Regulation[12].

The Gaia-X Trust framework specification was published in April of 2022[13], though to be able to use it an implementation of the federation services is required, which is still under development[14]. At the time of writing the Self-Description specification also lacks details.

From the perspective of INSPIRE, the Trust Framework may allow a party that is interested in geospatial data to verify that the actor that is supplying the data is authorised by the Member State to supply the data in question.

4.2 Federated Catalogue & Federation Services

The federated catalogue is how participants find each other. Although the full design is not finished yet, a first specification has been released[15] and the first implementation is being worked on[16]. The catalogue will be able to run either stand-alone or in a distributed architecture. Because the Self-

[11] https://esignature.ec.europa.eu/efda/tl-browser
[12] https://digital-strategy.ec.europa.eu/en/policies/eidas-regulation
[13] https://docs.gaia-x.eu/policy-rules-committee/trust-framework/22.04/
[14] https://www.gxfs.eu/specifications/
[15] https://www.gxfs.eu/core-catalogue-features/
[16] https://gitlab.com/gaia-x/data-infrastructure-federation-services/cat/

Descriptions are linked data, the catalogue can use a graph database[17] to allow complex semantic queries on the registered Self-Descriptions.

Some typical aspects this involves are:

- Finding data & publishers using semantic queries;
- Distributed architecture avoids a single point of failure;
- Checks if Self-Descriptions conform to the ontology schema defined by the ecosystem.

INSPIRE already has a portal cataloguing all available data sets of all Member States. Nevertheless, the Gaia-X federated catalogue can bring benefits for INSPIRE. A semi-standardised semantic search interface may make INSPIRE data better findable. A challenge will be automating the mapping between INSPIRE and Gaia-X. A key aspect to combine INSPIRE and Gaia-X is that Gaia-X Self-Descriptions are semantic JSON-LD documents. To add INSPIRE defined keywords, concepts, associations and attributes to a Self-Description these keywords, concepts, associations and attributes must be defined in a set of ontologies or vocabularies with accompanying Shapes Constraint Language (SHACL)[18] definitions for validation. Extension of the INSPIRE Feature Concept Registry through inclusion of the attributes and associations on these classes would be of great help in this endeavour.

4.3 Compliance

This building-block deals with validation and correctness. Some typical aspects this involves are:

- Gaia-X rules & (non-technical) onboarding: How does an organisation join a Gaia-X ecosystem. What are the (ecosystem-specific) schemas that Self-Descriptions must follow.
- Is a Self-Description valid and correct: Does a Self-Description match the schemas that the ecosystem specifies and are the facts stated in the Self-Description truthful? This last aspect ties in with the Identity and Trust block of Gaia-X.

The compliance section of Gaia-X does not offer many extra benefits to INSPIRE, since the INSPIRE (meta)data is already checked for compliance with the INSPIRE directives.

4.4 Data Sovereignty

Data sovereignty is about who is allowed to do what with the data. Can users see or download the data, or can users only run (accredited) algorithms on the data and download the results without being able to see the original data (compute to data). Is the user required to delete the data after a certain time, and is this deletion protocolled.

For INSPIRE the topic of data sovereignty is not particularly important, since the large majority of INSPIRE data is open for use. There are, however, data sets that can currently not be published in full detail due to, for instance, GDPR-concerns and that would benefit from data sovereignty controls.

[17] A graph database (GDB) is a database that uses graph structures for semantic queries with nodes, edges, and properties to represent and store data.
[18] https://www.w3.org/TR/shacl/

5 Use-cases

This chapter lists use-cases from the user-view. These use-cases are based on the API4INSPIRE[19] and GeoE3[20] projects. These two projects were chosen since they already have defined use-cases that directly use INSPIRE data or could benefit from INSPIRE data. GeoE3 defines not just data sources, but also services that handle data processing and fusion. These services can also be described in Gaia-X and made findable for users. The interesting aspects of Gaia-X that were identified in chapter 4 are also evaluated for each of these use-cases to rate how important each aspect is for the given use-case.

5.1 Franco-Germanic Flow

The river Rhine offers some good opportunities for testing cross-domain and cross-country data share as envisioned by Gaia-X and INSPIRE. The river forms part of the border between France and Germany (see Figure 4), and rivers involve many different data types, like:

- river structure,
- flood-planes,
- water height,
- water quality

Users searching for data on the Rhine may find data from different organisations, in different languages. More information about this use-case can be found on the API4INSPIRE homepage[21].

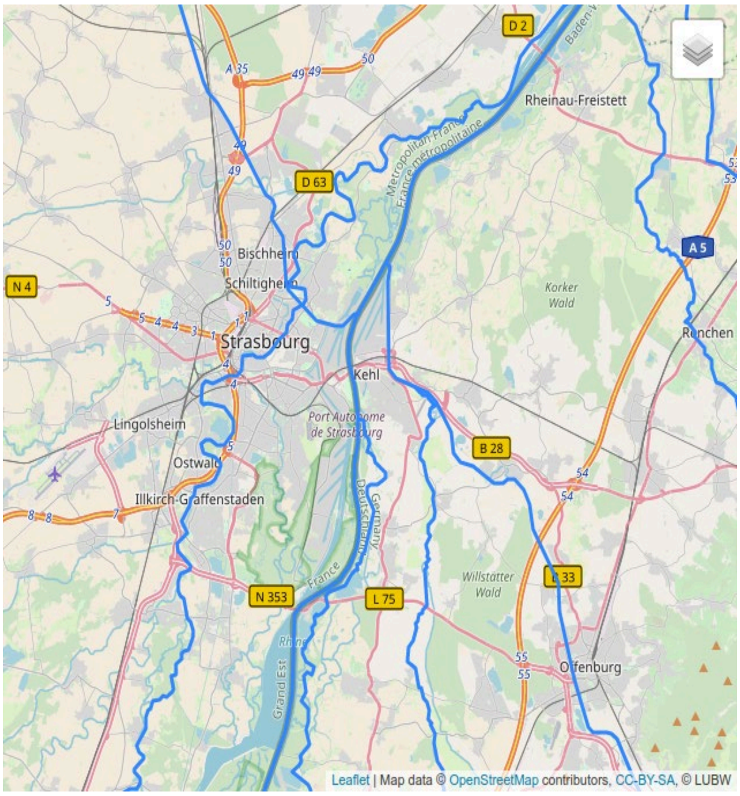


Figure 4: The geographic location of the use-case

[19] https://joinup.ec.europa.eu/collection/elise-european-location-interoperability-solutions-e-government/api-inspire
[20] https://geoe3.eu/
[21] https://datacoveeu.github.io/API4INSPIRE/datanests/franco-germanic-flow.html

A possible use-case from the end-user point of view could be a citizen using the fictional "can I swim here" app on his smartphone to check the water quality of his favourite swimming spot in the Rhine. To function, this app would need several types of data:

- The best swimming spots near the user
- Water bodies related to these swimming spots
- Water quality measurement sites for these water bodies

For cross-border rivers like the Rhine, the data may be available in different services in different countries.

5.1.1 Gaia-X benefits for this use-case

Identity & Trust: The quality of swimming water is a matter of public health, even though it is not of direct life-or-death importance. As such, the authenticity of the data in this use-case is very important.

Federated Catalogue: Surface water quality is part of the hydrography INSPIRE theme and as such it is very likely that relevant data is found in the INSPIRE Geoportal. Even so, it is possible that municipalities offer more up-to-date information about local water quality.

Compliance: Finding relevant data depends on the descriptions that represent the data in the catalogue. Automatic enforcement of INSPIRE specifications[22] may be possible, at least for the metadata in the Self-Descriptions of the services.

Data Sovereignty: It is not likely that data sovereignty plays a role in this use-case.

[22] https://inspire.ec.europa.eu/inspire-directive/2

5.2 Smart Transport in Smart Cities

This use-case combines data from the Urban Data Platform Hamburg[23] and the GeoE3 project[24].

While smart city systems tend to have data from fewer organisations, and generally more centralised, the data still covers many different themes. Smart city solutions are appearing in many places, but a key challenge and opportunity exists in making these systems seamlessly usable for visitors of the city and not just for the residents.

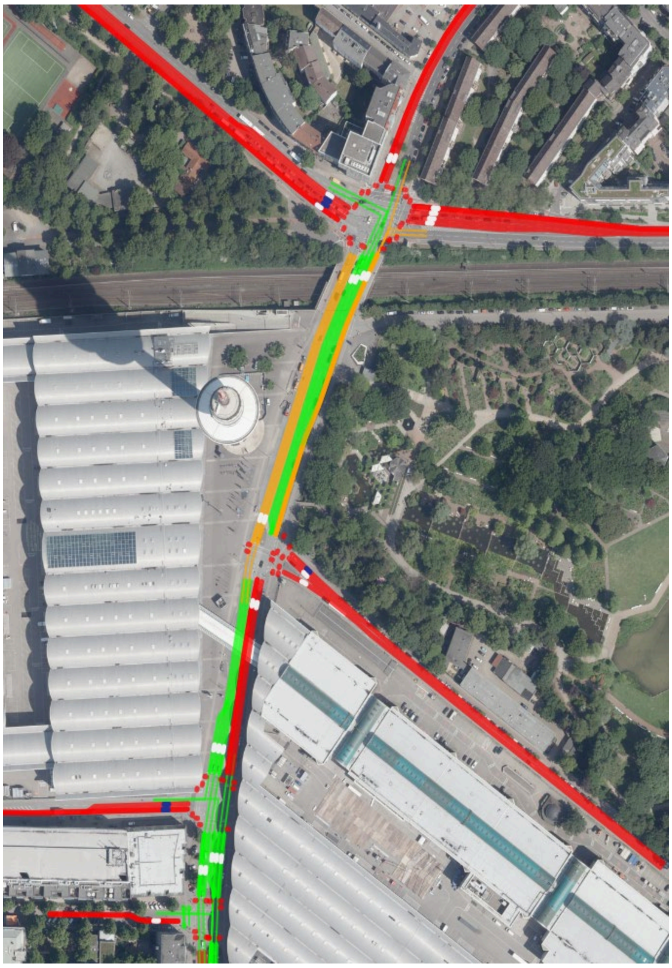


Figure 5: Visualised Traffic light data from the Urban Data Platform Hamburg[25]

The use-case of smart transport serves to produce data services that enable the better assessment of the energy consumption of electric vehicles. It can also support driver assistance systems of heavy vehicles that, for example, help the driver to change gears and define the most optimal driving speed. Another goal of the service is to provide traffic sign and speed limit data, as well as traffic and weather reports.

Key datasets include road networks, traffic light status, elevation models, weather and traffic data.

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[23] https://datacoveeu.github.io/API4INSPIRE/datanests/hamburg.html
[24] https://geoe3.eu/category/use-cases/smart-cities/
[25] https://geoportal-hamburg.de/geo-online/?Map/layerIds=12883,12884,16101,19969,94,19968,23219,23214,23221,23216,23212,23210&Map/center=[565083,5935345]&Map/zoomLevel=9

5.2.1 Gaia-X benefits for this use-case

Identity & Trust: Driving is a very security- and safety-sensitive activity. Therefore, it is particularly important that the data that is used is really coming from the party that it is expected to be coming from and has not been tampered with.

Federated Catalogue: Cars tend to drive around and visit different cities. Each city, area or country is likely to have its own platform serving data. The federated catalogue may make it possible to automatically find relevant data for the city/area the car is currently in.

Compliance: Finding relevant data depends on the descriptions that represent the data in the catalogue. Automatic enforcement of any relevant INSPIRE specifications may be possible.

Data Sovereignty: Anonymisation of data, and compute-to-data may make it possible to use GDPR- or otherwise sensitive data in route planning.

5.3 Optimising the heating and cooling system of a building

This use-case comes from the GeoE3 project: https://geoe3.eu/use-cases/.

When designing a new building, its heating and cooling facilities are planned in the context of the environmental effects (like exposure to sun and wind) at the building's proposed geographical location. Therefore, the architectural model must be available in a georeferenced form. The input datasets for the analysis on an adequate quality and harmonization level, and with permanent feature IDs for integration of external data, are available on the GeoE3 platform. They include:

- 3D building model with LoD 2 detail
- A Digital Surface Model (DSM) of the surrounding area
- Permeability info for the DSM
- Shadow index coverage
- Average wind conditions
- Normal air temperature at the nearest observation station
- Monthly mean temperature based on climate scenarios.

To support this use-case GeoE3 uses analysis functions deployed on the GeoE3 platform. These analysis functions may be useful to other use-cases that are currently not considered by the GeoE3 project. To give users the ability to find and use these analysis functions for their own use-cases these functions can be can also be offered as a service and published in the Gaia-X catalogue.

An optimal plan of the heating/cooling facilities for the designed building considers the environment at the building site and the anticipated future effects of climate change on the local weather situation. Architectural planning is based on a real, georeferenced model, where actual environmental factors and localized future climate scenarios can be considered.

Significant savings are achieved by optimizing the heating systems of buildings. Reliable predictions of the necessary cooling facilities can also be made. By expanding the planning area, an analysis can be made of benefits that a centralized heating/cooling facility might provide over a per-building installation. The analysis might also be applied so that the exact location of the building in the target area is optimized to minimize the cost related to heating and cooling.

5.3.1 Gaia-X benefits for this use-case

Identity & Trust: While trust is not insignificant for this use-case, it is not likely that the data sources for this use-case are falsified. This use-case does not depend on highly reliable, real-time data.

Federated Catalogue: The Federated Catalogue may make it easier for project planers to find relevant, up-to-date data sources.

Compliance: Finding relevant data depends on the descriptions that represent the data in the catalogue. Automatic enforcement of any relevant INSPIRE specifications may be possible.

Data Sovereignty: It is not likely that data sovereignty plays a role in this use-case. If the use-case were to be extended to existing buildings, the details of these existing buildings would need to be protected.

5.4 Analysing the efficiency of expansion of urban land

This use-case comes from the GeoE3 project: https://geoe3.eu/use-cases/.

The efficiency of an urban expansion plan is evaluated by analysing the compactness of the new development. The measure to be used is the ratio between land consumption and the population growth in the development area (UN SDG indicator 11.3.1). A comparison is made between the "UN SDG indicator 11.3.1" of the area before and after the planned expansion with respect to regional councils.

Expansion plans must be available with estimates of land consumption and predicted population capacity. The input datasets for the analysis, available from the GeoE3 platform, on an adequate quality and harmonization level, and with permanent feature IDs for integration of external data:

- Building footprints
- Existing population data

Analysis functions that GeoE3 provides to support the user in performing the tasks of the use-case. Analysis functions can also be offered as a service in Gaia-X.

Regional planning is based on reliable facts on the efficiency of the planned developments, compared with the existing situation in the target area. Urban area can be expanded in a sustainable way. The analysis can be extended to cover cross-border target areas.

5.4.1 Gaia-X benefits for this use-case

Identity & Trust: Such an analysis is likely to be done by, or on behalf of, local government. Since this local government is also the source of the required data, identity and trust issues are not a high priority.

Federated Catalogue: The analysis is most likely done by, or on behalf of, local government, with this local government being the main data provider. As such, additional data is not likely to be needed.

Compliance: Finding relevant data depends on the descriptions that represent the data in the catalogue. Automatic enforcement of any relevant INSPIRE specifications may be possible.

Data Sovereignty: The analysis may be done using non-public data. If so, it is important that, if an external party handles the analysis, this data is not accidentally released to the public or other parties.

5.5 Co-operative Intelligent Transport Systems

This use-case comes from the GeoE3 project: https://geoe3.eu/use-cases/. It combines data from GeoE3 with other public open data to provide new services for the European Cooperative Intelligent Transport Systems (C-ITS) platform.

This solution will provide 3D geospatial data for electric vehicles with a need to calculate how much power they will use to reach the top of a mountain pass, and how much they can recharge the batteries when they descend the mountain on the other side. It will also be useful as part of the ADAS (Automated Driver Assist System) in heavy goods vehicles (HGV), where the cruise control can take upcoming slopes and sharp curves on the road into account, before shifting gear. In addition, GeoE3 will provide traffic signs and speed limits to the vehicles, collected from the Norwegian and Finnish national road database (NVDB) found in Norway and Finland, as well as traffic alerts from traffic information (DATEX2) servers and weather alerts from the meteorological services.

Providers of C-ITS and ADAS services like road operators, fleet management systems, and navigation systems have backend systems that communicate with their vehicles either according to the C-ITS standards or the ADASIS specifications. They optimize trip planning to minimize energy/fuel usage, avoid trouble, and reduce travel time. Cost savings from reduced energy/fuel usage and reduced travel time outweighs the costs for implementing and maintaining this solution. Future plans include automatic booking of ferries, booking of charging/fuel stations, and booking of rest stops as part of the trip planning.

Data sources required for this use-case include:

- Road networks
- Live traffic statistics
- Predicted future traffic statistics

5.5.1 Gaia-X benefits for this use-case

Identity & Trust:	Driving is a very security- and safety-sensitive activity. Therefore, it is particularly important that the data that is to be used is really coming from the party that it is expected to be coming from and has not been tampered with. This pertains to both the source data coming from data providers and the processed data coming from GeoE3 services.
Federated Catalogue:	Each city, area or country is likely to have its own platform serving data. The federated catalogue may make it possible to automatically find relevant data for the city/area the car is currently in. The catalogue also makes it possible to offer the GeoE3 services to users worldwide.
Compliance:	Finding relevant data depends on the descriptions that represent the data in the catalogue. Automatic enforcement of any relevant INSPIRE specifications may be possible.
Data Sovereignty:	Anonymisation of data, and compute-to-data may make it possible to use GDPR- or otherwise sensitive data in route planning.

5.6 Overview of Gaia-X Advantages

This table shows the overview of the rating of how interesting the different aspects of Gaia-X are to the different use-cases, with a rating of 0 meaning “irrelevant to the use-case" and 3 being “highly relevant to the use-case”.

	Identity & Trust	Federated Catalogue	Compliance	Data Sovereignty	Total
F.G.-Flow	2	1	0	0	3
Smart Transport	3	2	0	1	6
Heating & Cooling	1	1	0	2	4
Urban Land Expansion	1	1	0	2	4
Automated Driving	3	2	0	1	6

The most interesting use-cases seem to be Automated Driving and Smart Transport. They rely the most on trustworthy data coming from a large variety of sources and can benefit very much from a federated catalogue that allows new sources to be found that can be independently verified on trustworthiness.

5.7 Mapping the GeoE3 and Gaia-X Architecture

The next step is matching the reference architecture use the use-cases with the Gaia-X architecture.

The GeoE3 project has defined a business reference model as depicted in the upper half of the image below. The lower half of the image shows how the entities in the GeoE3 model can be mapped to the main entities of the Gaia-X architecture.

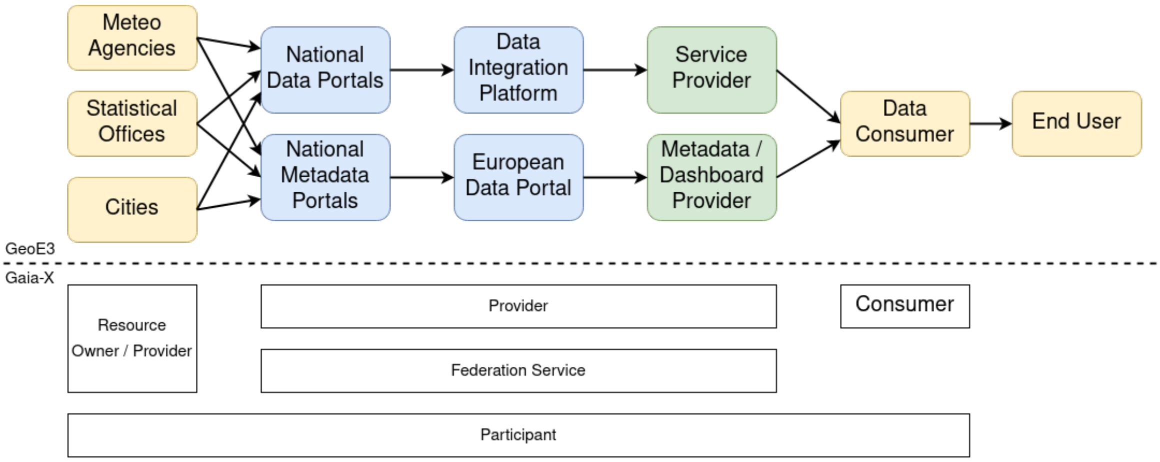

Figure 6: The GeoE3 reference model (source: https://geoe3.eu) mapped to entities from the Gaia-X architecture

The Meteorology Agencies, Statistical Offices and Cities entities are mapped to Resource Owner or Resource Provider concepts of the Gaia-X architecture. The National Data Portals, Data Integration Platform and Service Provider are mapped to the Provider concept, while the National Metadata Portals, European Data Portal and Metadata / Dashboard Provider entities are mapped to the Federation Service concept. The Data Consumer entity is mapped to the Consumer concept. Finally, all these entities are as well instances of the Participant concept. Details of these Gaia-X concepts can be found in the chapter General Actors in Gaia-X.

The Gaia-X conceptual model is displayed below. Besides the entities listed in the GeoE3 business model, it adds Resource and Service Offering.

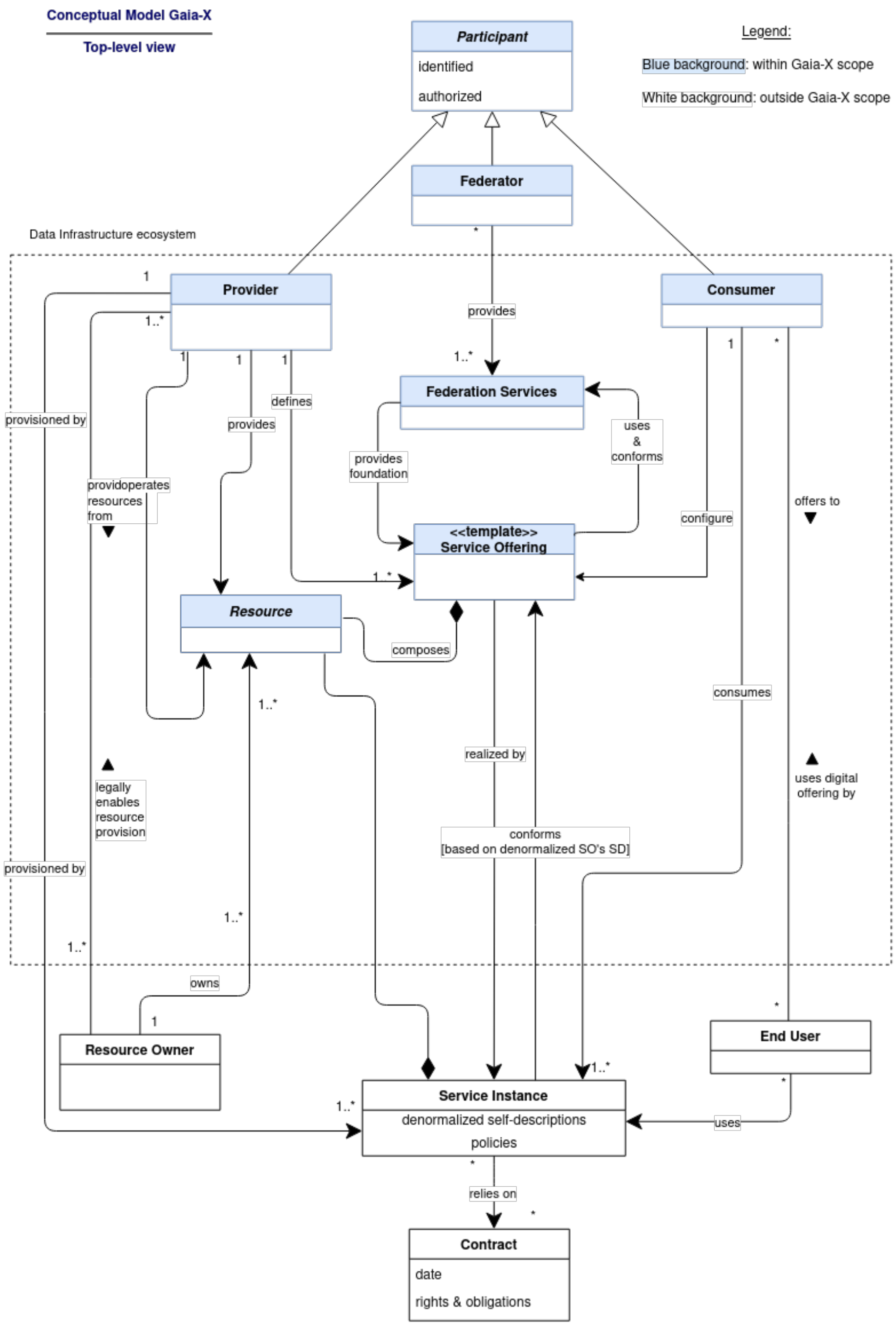

Figure 7: The Gaia-X conceptual model[26]

Each of the entities in the GeoE3 model can be mapped to the Gaia-X conceptual model. The "Resource" and "Service Offering" concepts are not depicted in the GeoE3 model, but they implicitly there in the form of the arrows in the model, since a GeoE3 "Data Consumer" would use a Service from a GeoE3 "Service Provider". This means that the GeoE3 model can be fully mapped to the Gaia-X model.

[26] https://gaia-x.eu/

6 Example Self-Description for a Service-Offering

The core concept in Gaia-X is that of the Self-Description. This chapter describes an example for how to create a Self-Description for a data service offering. The service offering chosen for this example is for a service that offers air-quality data. Several of the use cases described in chapter 5 can benefit from trusted air quality data, including the two most interesting use cases on Smart Transport and Automated Driving.

6.1 Use-case Description

ACME (A Company that Makes Everything) has a data set with air quality data that are updated hourly. They expose their data set using REST API that follows several data- and interface standards. ACME wants to offer their air quality data set and data service on the Gaia-X Marketplace.

6.2 Mapping to the Gaia-X Conceptual Model

In Gaia-X terminology, ACME is a *Provider* in this scenario and its air quality data is a *Resource* of type *Data Resource*. The Air quality service that serves the data is a *Service Offering* of type *Data Service Offering*. The Resource is owned by ACME as *Resource Owner*.

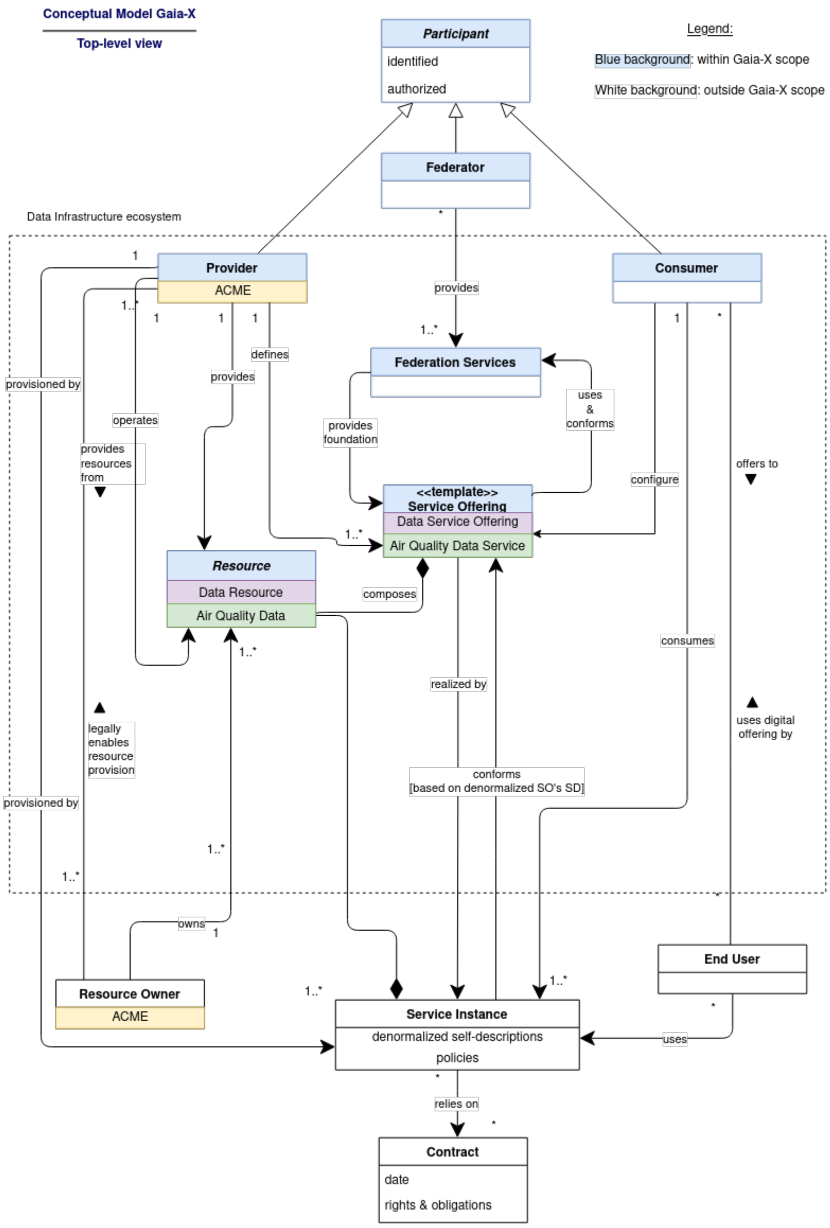

Figure 8: The air quality data service mapped to the Gaia-X conceptual architecture

The Data Service Offering Class inherits properties from the Service Offering class, and is composed of the DataResource, Standard and Endpoint classes:

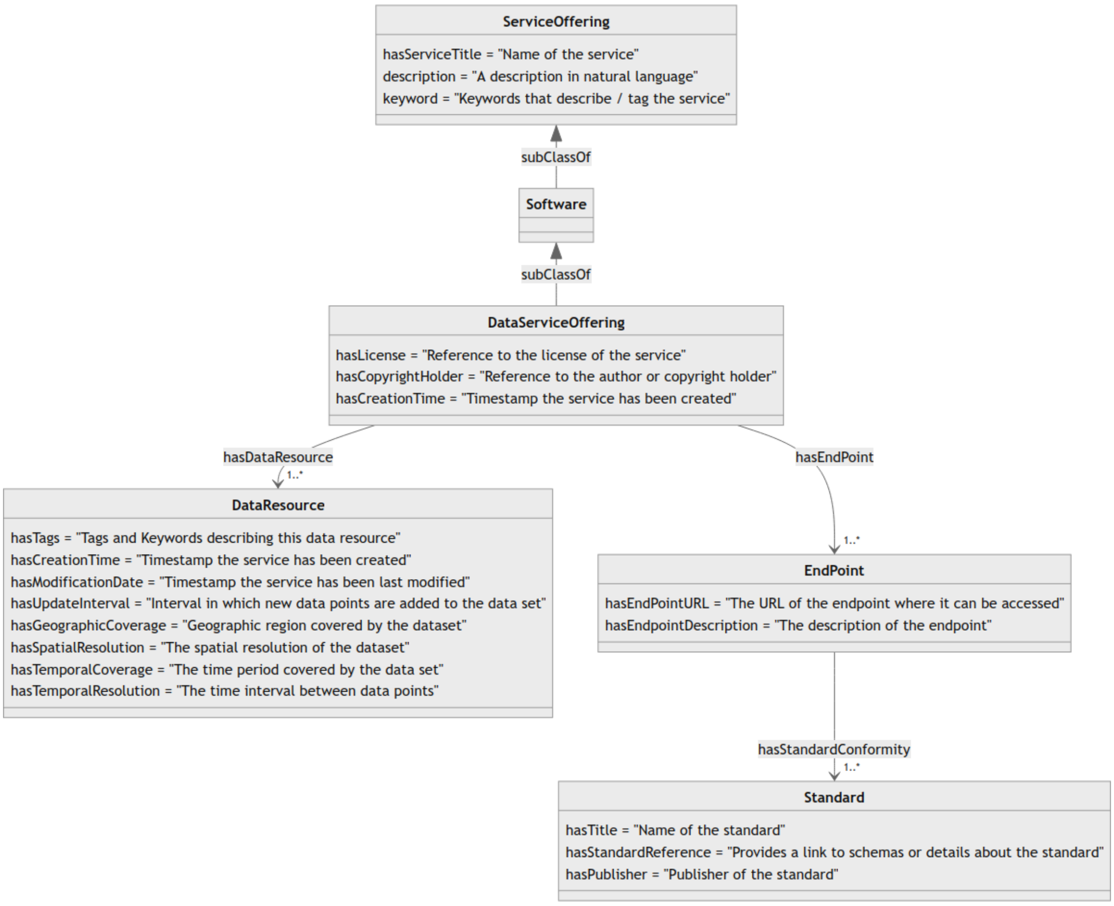

Figure 9: Class diagram for the ontology class DataServiceOffering

6.3 Creating a Self-Description

The next thing to do is write the Self-Description for the data service offering. The full example can be found in DataService_airquality.jsonld.

The JSON-LD context lists all ontologies referenced in the Self-Description.

```
"@context": {
  "dct": "http://purl.org/dc/terms/",
  "foaf": "http://xmlns.com/foaf/0.1/",
  "ids": "https://w3id.org/idsa/core/",
  "owl": "http://www.w3.org/2002/07/owl#",
  "rdf": "http://www.w3.org/1999/02/22-rdf-syntax-ns#",
  "rdfs": "http://www.w3.org/2000/01/rdf-schema#",
  "schema": "http://schema.org/",
  "vcard": "https://www.w3.org/2006/vcard/ns#",
  "xsd": "http://www.w3.org/2001/XMLSchema#",
  "gax": "http://w3id.org/gaia-x/core#",
  "gax-service": "http://w3id.org/gaia-x/service#",
  "sosa": "http://www.w3.org/ns/sosa/",
  "ex": "http://example.org/"
},
```

The type of a data service offering as defined by Gaia-X is DataServiceOffering:

```
"@type": "gax-service:DataServiceOffering",
```

Since a DataServiceOffering is a ServiceOffering, the Self-Description needs all the properties and associations of a ServiceOffering. The “isDefinedBy” association points to a Participant of the Gaia-X ecosystem, and this Participant should also be described by its own Self-Description.


```
 "gax-service:hasServiceTitle": "European Air Quality Service",
  "dct:description": "A service providing air quality data around Europe.",
  "dcat:keyword": [
    "INSPIRE compliant"
  ],
  "gax:isDefinedBy": {
    "@id": "ex:ACMEProvider"
  },
  "gax:hasContactPoint": {
    "@id": "ex:ACMEProvider"
  }
```


Data always has a copyright holder, and a license. A data set is also created at some point in time. A Data Service Offering thus also needs that information:


```
 "gax-service:hasCopyrightHolder": {
    "@value": "ACME Inc.",
    "@type": "xsd:string"
  },
  "gax-service:hasLicense": {
    "@value": "Public Domain",
    "@type": "xsd:string"
  },
  "gax-service:hasCreationTime": "2020-01-01T12:00:00Z"
```


A data service offering makes one or more data resources available, thus each data resource needs to be described:


```
"gax-service:hasDataResource": [
    {
      "inspire-fc:containedFeatureTypes": [
        "inspire-fc:EnvironmentalMonitoringFacility",
        "inspire-fc:ObservingCapability",
        "inspire-fc:Process",
        "inspire-fc:PointObservation",
        "inspire-fc:ObservableProperties"
       ],
      "gax-service:hasTags": ["air quality", "time series data", "measurements",
"NO", "NO2", "O3", "CO", "PM10", "PM2.5"],
      "gax-service:hasUpdateInterval": "PT1H",
      "gax-service:hasGeographicCoverage": "POLYGON((-11.18 36.6,-25.59 65.8,26.25
71.58,42.6 67.74,28.89 59.71,24.5 53.44,22.39 48.23,29.07 48.34,30.3 45.21,27.84
40.05,26.08 34.45,10.79 37.58,-11.18 36.60,-11.18 36.6))",
      "inspire-fc:ObservableProperties": [
        "eionet-aq:pollutant/1",
        "eionet-aq:pollutant/6001",
        "eionet-aq:pollutant/5",
        "eionet-aq:pollutant/38",
        "eionet-aq:pollutant/7",
        "eionet-aq:pollutant/8",
        "eionet-aq:pollutant/9",
        "eionet-aq:pollutant/10"
```

```
      ]
    }
  ]
```

Since there are many different types of data, it is impossible to describe all with just a single ontology. Therefore, it is very likely that some domain-specific ontology is needed to properly describe the data. In this case the Sensor-Observation-Sampling-Actuator (SOSA) ontology is used to describe the data.

Finally, the data is made available through service endpoints. Each endpoint needs to be described so that the client knows how to access the data. Each endpoint can also implement certain interface or data standards:

```
 "gax-service:endpoint": [
    {
      "gax-service:hasEndPointURL": "https://airquality-frost.k8s.ilt-dmz.iosb.fraunhofer.de/v1.1",
      "gax-service:endpointDocumentation": 
"https://datacoveeu.github.io/API4INSPIRE/datanests/ad-hoc.html#ad-hoc-austrian-air-quality-api",
      "gax-service:hasEndpointDescription": "https://airquality-frost.k8s.ilt-dmz.iosb.fraunhofer.de/v1.1/api",
      "gax-service:hasStandardConformity": [
        {
          "gax-service:hasTitle": "OGC SensorThings API",
          "gax-service:hasStandardReference": 
"http://www.opengis.net/doc/is/sensorthings/1.1",
          "gax-service:hasPublisher": "Open Geospatial Consortium"
        },
        {
          "gax-service:hasTitle": "OGC Observations, Measurements and Samples",
          "gax-service:hasStandardReference": "https://www.ogc.org/standards/om",
          "gax-service:hasPublisher": "Open Geospatial Consortium"
        }
      ]
    }
  ]
```

The full example can be found in

7 Conclusion

Chapter 5 presented several use-cases and discussed the potential of benefits to get from applying Gaia-X concepts and technologies to INSPIRE. The results proof that there is a high potential in Gaia-X. However, several areas are still in a conceptual phase and not available is testable solutions. Therefore, the results need to be taken with care.

The area which is most advanced in Gaia-X is the specification of the Self-Description and its' application in a catalogue. This could already be used to show a real-world example and gives a basic understanding of the complexity of such a task and the benefits of the results.

As soon as the implementations for the 4 building blocks of Gaia-X are available (expected in December 2022 or January 2023) one or more full end-to-end use-case should be implemented and evaluated.

Annex A: DataService_airquality.jsonld. This Self-Description contains claims, but they are not yet signed, and thus not verifiable yet. How signing and verification works will be part of future work.

8 Conclusion

Chapter 5 presented several use-cases and discussed the potential of benefits to get from applying Gaia-X concepts and technologies to INSPIRE. The results proof that there is a high potential in Gaia-X. However, several areas are still in a conceptual phase and not available is testable solutions. Therefore, the results need to be taken with care.

The area which is most advanced in Gaia-X is the specification of the Self-Description and its' application in a catalogue. This could already be used to show a real-world example and gives a basic understanding of the complexity of such a task and the benefits of the results.

As soon as the implementations for the 4 building blocks of Gaia-X are available (expected in December 2022 or January 2023) one or more full end-to-end use-case should be implemented and evaluated.

9 Annex A: DataService_airquality.jsonld


```
{
  "@context": {
    "dct": "http://purl.org/dc/terms/",
    "xsd": "http://www.w3.org/2001/XMLSchema#",
    "gax": "http://w3id.org/gaia-x/core#",
    "gax-service": "http://w3id.org/gaia-x/service#",
    "sosa": "http://www.w3.org/ns/sosa/",
    "inspire-fc": "https://inspire.ec.europa.eu/featureconcept/",
    "ex": "http://example.org/",
    "eionet-aq": "http://dd.eionet.europa.eu/vocabulary/aq/"
  },
  "@id": "ex:AirQualityDataService",
  "@type": "gax-service:DataServiceOffering",
  "gax-service:hasServiceTitle": "European Air Quality Serivice",
  "dct:description": "A service providing airquality data around europe.",
  "dcat:keyword": [
    "INSPIRE compliant"
  ],
  "gax:isDefinedBy": {
    "@id": "ex:ACMEProvider"
  },
  "gax:hasContactPoint": {
    "@id": "ex:ACMEProvider"
  },
  "gax-service:hasCopyrightHolder": {
    "@value": "ACME Inc.",
    "@type": "xsd:string"
  },
  "gax-service:hasLicense": {
    "@value": "Public Domain",
    "@type": "xsd:string"
  },
  "gax-service:hasCreationTime": "2020-01-01T12:00:00Z",
  "gax-service:hasDataResource": [
    {
      "inspire-fc:containedFeatureTypes": [
        "inspire-fc:EnvironmentalMonitoringFacility",
        "inspire-fc:ObservingCapability",
        "inspire-fc:Process",
        "inspire-fc:PointObservation",
        "inspire-fc:ObservableProperties"
       ],
      "gax-service:hasTags": ["air quality", "time series data", "measurements",
"NO", "NO2", "O3", "CO", "PM10", "PM2.5"],
      "gax-service:hasUpdateInterval": "PT1H",
      "gax-service:hasGeographicCoverage": "POLYGON((-11.18 36.6,-25.59 65.8,26.25
71.58,42.6 67.74,28.89 59.71,24.5 53.44,22.39 48.23,29.07 48.34,30.3 45.21,27.84
40.05,26.08 34.45,10.79 37.58,-11.18 36.60,-11.18 36.6))",
      "inspire-fc:ObservableProperties": [
        "eionet-aq:pollutant/1",
        "eionet-aq:pollutant/6001",
        "eionet-aq:pollutant/5",
        "eionet-aq:pollutant/38",
```

```
        "eionet-aq:pollutant/7",
        "eionet-aq:pollutant/8",
        "eionet-aq:pollutant/9",
        "eionet-aq:pollutant/10"
      ]
    }
  ],
  "gax-service:endpoint": [
    {
      "gax-service:hasEndPointURL": "https://airquality-frost.k8s.ilt-
dmz.iosb.fraunhofer.de/v1.1",
      "gax-service:endpointDocumentation":
"https://datacoveeu.github.io/API4INSPIRE/datanests/ad-hoc.html#ad-hoc-austrian-
air-quality-api",
      "gax-service:hasEndpointDescription": "https://airquality-frost.k8s.ilt-
dmz.iosb.fraunhofer.de/v1.1/api",
      "gax-service:hasStandardConformity": [
        {
          "@type": "gax-service:DataAccessStandard",
          "gax-service:hasTitle": "OGC SensorThings API",
          "gax-service:hasStandardReference":
"http://www.opengis.net/doc/is/sensorthings/1.1",
          "gax-service:hasPublisher": "Open Geospatial Consortium"
        },
        {
          "@type": "gax-service:DataModellingStandard",
          "gax-service:hasTitle": "OGC Observations, Measurements and Samples",
          "gax-service:hasStandardReference": "https://www.ogc.org/standards/om",
          "gax-service:hasPublisher": "Open Geospatial Consortium",
          "gax-service:modelType": "conceptual"
        }
      ]
    }
  ]
}
```