



DOME 4.0

Deliverable D3.2 - “Ecosystem information model ontology”

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Publishable Summary

This document describes the DOME 4.0 Ecosystem Ontology, that includes the concepts needed on the DOME 4.0 platform to integrate multiple sources of data and services. It also addresses the alignment of this ontology to the Elementary Multiperspective Ontology (EMMO) and the connection to other pre-existing assets.

Executive Summary

This document describes the DOME 4.0 Ecosystem Ontology, that includes the concepts needed on the DOME 4.0 platform to integrate multiple sources of data and services. It also addresses the alignment of this ontology to the Elementary Multiperspective Ontology (EMMO) and the connection to other pre-existing assets.

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1 Introduction

This document reports on the activities of Task 3.2 of DOME 4.0 project, “Ecosystem Information Model”. The main outcome of this task is the DOME 4.0 Ecosystem Ontology¹ [available on the [DOME 4.0 website](#)], which collects the concepts needed in a two-sided marketplace for data and services. Additionally, a module of alignment to the EMMO has been developed (ADE, Alignment of DOME 4.0 and EMMO) [available on the [DOME 4.0 website](#)].

The aim of the Ecosystem Ontology is to provide a light formal vocabulary to support the integration of multiple web-based sources of data and services, in the area of materials and manufacturing. Therefore, it includes concepts such as: platform, catalogue, dataset, service, topic, and offering. It directly connects to D3.1 “Semantic data exchange ontology” and uses information from D2.1 “Technical requirements for data tools and services” (e.g., “action” types were identified from the user stories) and D4.1 “Report on data availability, data structure, and data requirements for each showcase” (e.g., “standard identifiers” and file formats used in the showcases). This ontology is used by core components of the DOME 4.0 platform, as the front-end user interface (e.g., the available filtering options and fields for registration), the semantic broker and connectors to other platforms.

Task 3.2 work has been carried out in close connection with the DOME 4.0 platform developers, considering the broad scope of the project showcases and in consultation with the exploitation work-package for the business-related concepts. Whenever possible, existing assets have been reused. The criteria we employed to decide on reuse have included: availability as semantic technology assets (i.e., RDF-like), maturity level, wide usage, relevance for specific domains, composability, alignment to the EMMO and/or to the OntoCommons Ecosystem. The development has been iterative and has proceeded in parallel with the gathering of relevant information; to facilitate collaboration, we have used a document and a graphical tool (MIRO² board) to collect input and feedback on the concepts, whereas the actual ontology development has happened in GitHub and using Protégé.

This document is structured as follows: in Section 2 we list the main concepts of the ecosystem ontology; in Section 3 we describe the alignment to the EMMO and in Section 4 we mention the main connections to other pre-existing semantic assets and initiatives. Finally, we conclude in Section 5. In the Annexes we list relevant assets, digital marketplaces and projects, which have informed our developments, and give an example of the ontology concepts.

¹ In this document we refer to version 1.0.0 of the DOME 4.0 Ecosystem Ontology.

² <https://miro.com/>

2 Main concepts

In this section we give an overview of the DOME 4.0 Ecosystem Ontology. It is an ontology using OWL language, written in Turtle (.TTL) format, and its purpose is to support the integration of multiple web-based sources of data and services. It contains both concepts that are relevant from the user perspective (e.g., categories for filters in the UI) as well as concepts that are needed from the technical side (e.g., the URL at which a certain web-service is provided).

In Figure 1 we show the central concept, “platform”, and the main related ones, together with the (object) properties connecting them.

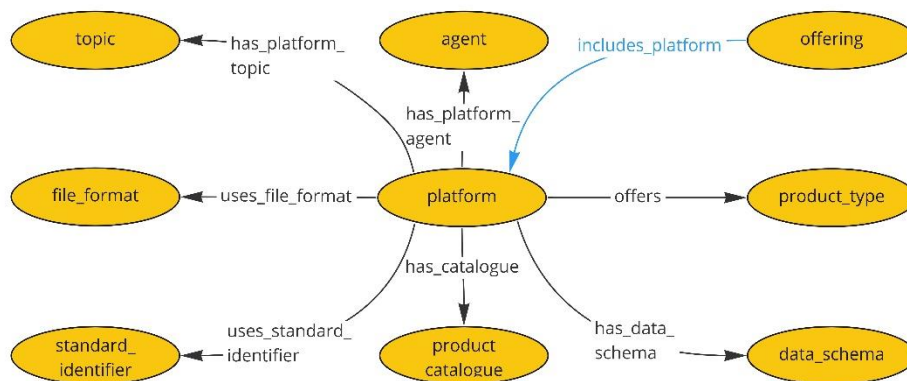


Figure 1: Selection of classes from the DOME 4.0 Ecosystem Ontology. The `dome-core:platform` class and main related ones are shown. Ellipses stay for classes, and arrows for properties. This and similar images have been generated using MIRO.

Below we list some of the major ecosystem concepts with brief elucidations (for more details please see the ontology source):

- `dome-core:platform`: a web-based platform offering products, data and data services;
- `dome-core:platform_type`: classification of platforms used by DOME 4.0, from the perspective of data flow and connectors. Its subclasses include:
 - `data_provider`: provider of data that exists already, is stored and can be obtained immediately upon request;
 - `data_on_demand_provider`: provider of data on demand, i.e., upon sending a request, one gets a receipt, then the data, possibly after some time;
 - `Interactive_app_provider`: provider of interactive application, i.e., one logs in and can perform actions;
 - `consumer`: a platform that consumes data, a data sink;
- `dome-core:agent`: an agent in the EVMPO sense, i.e., somebody that can act on the marketplace ecosystem. Its subclasses include: `dome-core:platform_owner`, `dome-core:platform_maintainer`, `dome-core:platform_user`. These can be used as roles in KeyCloack;
- `dome-core:topic`: topic, theme, domain, to be taken from a widely used list. A concrete set of topics (`dome-core:LIST_OF_TOPICS`, a `skos:ConceptScheme`) is used as a filter in the DOME 4.0 search

interface: it is an extract of the larger EuroSciVoc taxonomy (cf. Section 0) and can be used as a target of the `dcat:themeTaxonomy` property (cf. DCAT-2);

- *dome-core:product_catalogue*: catalogue of products (cf. Figure 2), which could be given as a DCAT one or not. It is a superclass of `dcat:Catalog`;
- *dome-core:product_type*: a tag, used to categorize products, includes elements³: EQUIPMENT, EXPERIMENTAL_DATA, MATERIAL_PROPERTY, MODELLING_DATA, OBSERVATIONAL_DATA, PATENT, PUBLICATION, RAW_MATERIAL, SOFTWARE;
- *dome-core:standard_identifier*: a string widely used to identify an entity in the materials and manufacturing domain, includes elements: CAS_NUMBER, EC_NUMBER, IUPAC_INCHI, SMILES;
- *dome-core:offering*: offering/bundle of data and/or data services on DOME 4.0 (not directly related to, but inspired by PaasPort, GoodRelations and IDS concepts, cf. Appendix 1). Its direct (disjoint) subclasses are *dome-core:offering_subscription* and *dome-core:offering_one_off_sale*. In turn, the first one has (disjoint) direct subclasses *dome-core:offering_by_usage* and *dome-core:offering_flat* (cf. Figure 3, where the respective properties are also shown);
- *dome-core:service*: a web service, as in MSM (cf. Section 4). It is a superclass of `dcat:DataService`;
- *dome-core:operation*: part of a web service, as in MSM. E.g., a block that carries out a function;
- *dome-core:action*: action. In particular, actions on data can be used to characterize services and operations (cf. Figure 2). The class includes elements:
 - *dome-core:VIEW*: Read and visualize data, with no changes or additions (cf. RoMM);
 - *dome-core:TRANSFORM*: Change the data without altering the physical state itself (e.g., change the numerical representation of a state, cf. RoMM).
 - *dome-core:EXTRACT*: Enrich the dataset by further information calculated based on the information already contained in the dataset. E.g., averaging and interpolation (cf. RoMM).
 - *dome-core:SIMULATE*: Perform a physics-based or data-based simulation (cf. RoMM).
 - Search actions, such as: SEARCH_BY_EXACT_STRING_MATCH, SEARCH_WITH_FILTER, SEARCH_WITH_WILD_CARD, SEARCH_WITH_LOGICAL_OPERATOR.

In Figure 2 we show an extract of concepts and properties with a focus on product catalogue and services. In Figure 3 we show a view on business-related concepts.

³ Note: for the sake of readability, the "*dome-core*" prefix is omitted here and in other lists below, when there is no risk of confusion.

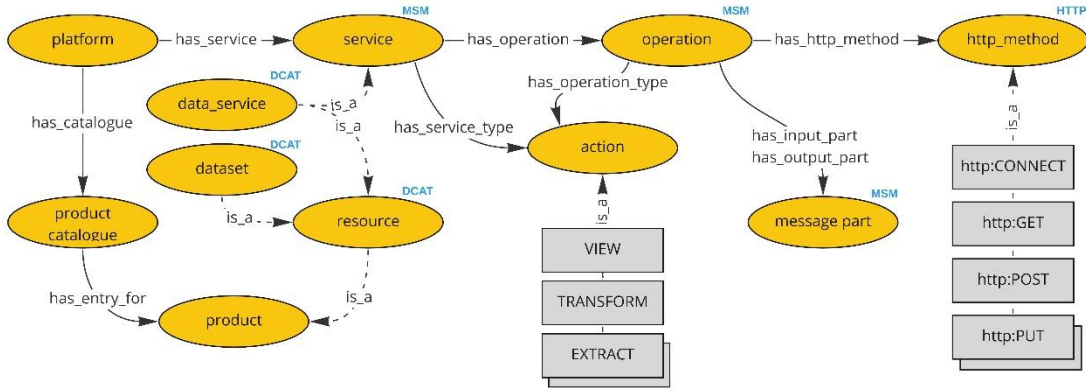


Figure 2: Selection of classes from the DOME 4.0 Ecosystem Ontology, Extract focusing on dome-core:product_catalogue, dome-core:service and main related classes. Properties are also shown. Concepts from MSM, HTTP and DCAT vocabularies are reused. Rectangles stay for individuals and ellipses for classes; overlaid rectangles indicate that the class contains further individuals beside those explicitly shown.

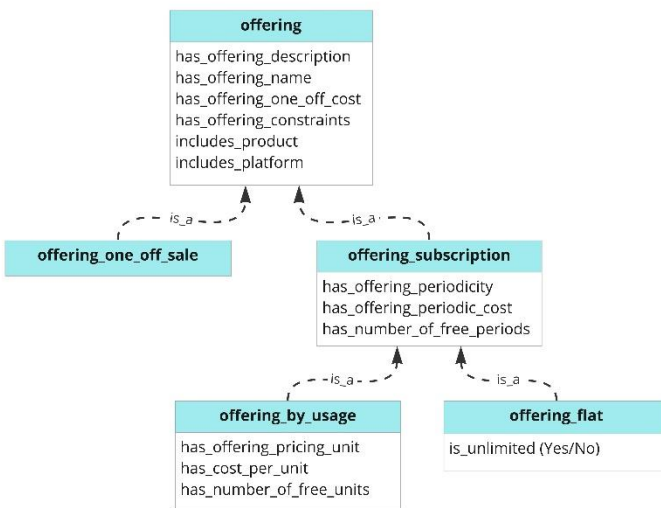


Figure 3: Selection of classes from the DOME 4.0 Ecosystem Ontology, on the business side. View of the dome-core:offering class, its subclasses and their properties.

3 Alignment to the EMMO

All the concepts (classes and individual entities) from the DOME 4.0 Ecosystem Ontology have been aligned, also thanks to discussions with EMMO authors, to concepts from the current (development) version of EMMO, version 1.0.0-beta⁴. This is done in a separate module, ADE, that stays for “Alignment of DOME 4.0 and EMMO”⁵.

The connections are made using these constructs: *owl:equivalentClass*, *rdfs:subClassOf* and *rdf:type*.

As an example, we list below some of the statements, a selection of which is also shown in Figure 4, including the EMMO “perspective” parent class:

- dome-core:platform rdfs:subClassOf emmo:Software.
- dome-core:agent rdfs:subClassOf emmo:IntentionalAgent.
- dome-core:topic rdfs:subClassOf emmo:Coded.
- dome-core:product_catalogue rdfs:subClassOf emmo:Document, emmo:Information.
- dome-core:file_format rdfs:subClassOf emmo:Language, emmo:Coded.
- dome-core:action rdfs:subClassOf emmo:IntentionalProcess.
- dome-core:product_type rdfs:subClassOf emmo:Coded.
- dome-core:dataset rdfs:subClassOf [a owl:Class; owl:unionOf (emmo:Datum emmo:DataSet)], emmo:Information, emmo:Document .
- dome-core:service rdfs:subClassOf emmo:Software, emmo:Workflow .
- dome-core:operation rdfs:subClassOf emmo:Software, emmo:Task .

⁴ <https://github.com/emmo-repo/EMMO/tree/1.0.0-beta4>, as it is at the time of writing this document (November 2022).

⁵ Here we document version 0.8.2 of ADE.

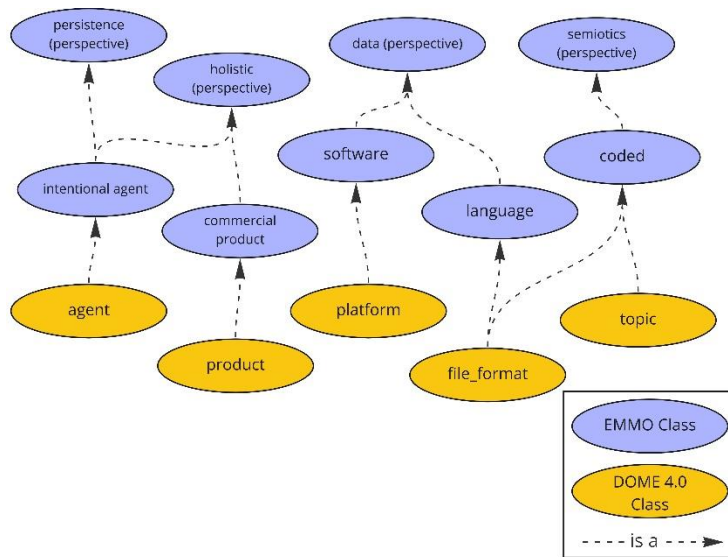


Figure 4: Selection of alignments of classes DOME 4.0 Ecosystem Ontology to EMMO classes.

We note that EMMO uses alphanumerical IRIs for its entities (e.g., the IRI for “Software” is `emmo:EMMO_8681074a_e225_4e38_b586_e85b0f43ce38`). For the sake of readability, in this document and in ADE we use `skos:prefLabel-s` instead. This mapping is automatically carried out with a Python tool using the `ontopy` module⁶, and the result is available on the [DOME 4.0 website](#).

⁶ <https://pypi.org/project/ontopy/>

4 Connection to previous developments

In this section we highlight the main previous (and ongoing) efforts to which the DOME 4.0 Ecosystem Ontology connects, either directly or indirectly. While most of them are formal semantic assets (RDF-like), some are standard knowledge sources (e.g., RoMM is a book containing various taxonomies). For each entry we mention what elements have been reused.

Data Catalog Vocabulary (DCAT)

The Data Catalog Vocabulary (DCAT) is an RDF vocabulary and a W3C recommendation for sharing data catalogues on the web. Here we especially use the `dcat:Catalog` concept; also important are: `dcat:DataService`, `dcat:Dataset`⁷ and `dcat:Resource`. Note: here we refer to the stable version DCAT-2⁸, but note in passing that a newer version is under development. Based on DCAT there are also application profiles, DCAT-AP and DCAT-US, widely used in Europe and USA respectively (mandated for public publishing across governmental bodies).

The European Science Vocabulary (EuroSciVoc)

The European Science Vocabulary (EuroSciVoc)⁹ is an RDF taxonomy of science topics managed by the Publications Office of the EU and used in the CORDIS website. It was created semi-automatically using natural language processing methods on a CORDIS corpus. It is multilingual, contains about 1000 topics, from humanities to agriculture, including engineering and natural sciences. In the DOME 4.0 user interface, we currently use a selection of topics, as relevant for the project showcases.

European Virtual MarketPlace Ontology (EVMPO) and VIMMP Ontologies

The European Virtual MarketPlace Ontology (EVMPO)¹⁰ is a mid-level ontology developed in a collaboration between the VIMMP, Marketplace and EMMC CSA projects. It collects few paradigmatic categories that were identified as necessary for a virtual marketplace for materials. Connected to it there are a set of eight domain ontologies (VIMMP Ontologies) that expand on the paradigmatic concepts: they provide a rich source of concepts and properties that can be directly reused within DOME 4.0.

FAIRsharing Data formats catalogue

One of the activities of the FAIRsharing.org¹¹ initiative is an ongoing effort of collecting data formats, tagging them and assigning DOIs. Within DOME 4.0 we refer to such DOIs whenever available¹².

⁷ This and related concepts are at the core of DOME 4.0 D3.1.

⁸ <https://www.w3.org/TR/vocab-dcat-2/>

⁹ <https://op.europa.eu/en/web/eu-vocabularies/euroscivoc>

¹⁰ M. T. Horsch *et al.*, *Data Technology in Materials Modelling*, Springer, 2021 (<https://doi.org/10.1007/978-3-030-68597-3>).

The repository for VIMMP Ontologies is at: <https://gitlab.com/vimmp-semantic/vimmp-ontologies>.

¹¹ S. A. Sansone, *et al.* FAIRsharing as a community approach to standards, repositories and policies. *Nat Biotechnol* **37**, 358–367 (2019). <https://doi.org/10.1038/s41587-019-0080-8>

¹² E.g., see the FAIRsharing page for TTL format: <https://doi.org/10.25504/FAIRsharing.3e194c>.

Minimal Service Model (MSM)

A minimal RDF model for web-services that was proposed within the SOA4All¹³ FP7 project (GA ID: 215219), as part of a broader effort, and covers the common denominator between service models. We use it (in a slightly adapted form) to enable a semantic description of REST APIs. On the general topic, that is still mostly confined to the academic world, we point the reader to recent surveys^{14, 15}.

Review of Materials Modelling (RoMM)

The Review of Materials Modelling¹⁶ is part of an effort to define a common vocabulary for materials modelling. Here we reuse some of its categories for data processing to define “action” types (e.g., where RoMM has “extractor” we have “EXTRACT” as a data action, and so on).

¹³ <https://cordis.europa.eu/project/id/215219>, Service Oriented Architectures for All – SOA4All.

¹⁴ R. Verborgh et al., “Survey of Semantic Description of REST APIs,” in REST: Advanced Research Topics and Practical Applications, C. Pautasso, E. Wilde, and R. Alarcón, Eds. Springer, 2014, pp. 69–89.

¹⁵ Cremaschi et al, Toward Automatic Semantic API Descriptions to Support Services Composition, https://doi.org/10.1007/978-3-319-67262-5_12.

¹⁶ A.F. de Baas (ed.), What Makes a Material Function? (EU Publications Office, Luxembourg, Let me compute the ways, 2017).

5 Conclusions / Next steps

In this document we have summarized DOME 4.0 Ecosystem Ontology and its connections to other (semantic and non-semantic) assets. It includes key concepts that are needed on the DOME 4.0 platform both on the user-facing and technical sides, and connects to EVMPO (mid-level ontology) and to the EMMO (top-level ontology).

This concludes the activities of DOME 4.0 Task 3.2. The task results are being and will be used by DOME 4.0 platform core components, as the user interface, the semantic broker and connectors to other platforms.

As any semantic asset, also the Ecosystem Ontology needs to be a “live” entity: while the bulk of its content will not change, whenever necessary, additions will be made in coordination with the platform developers and following best practices for metadata governance¹⁷.

In the next months, as part of maintenance activity, we will collaborate with the OntoCommons project to ensure the technical requirements for inclusion in the Ontology Commons EcoSystem (OCES) are followed. These activities will likely include: completing the set of annotations to provide details about the conceptualisation behind each OWL entity (class or property) and an alignment with the bridge concepts that are being identified by OntoCommons. In fact, OntoCommons is finalising in these weeks the technical specifications detailing what annotations will be required by the OCES, together with a well-defined set of bridge concepts.

¹⁷ See, e.g., VIMMP Deliverable 1.6, *Taxonomy editor: Taxonomy governance process*.

6 Lessons learnt

While the possibility to reuse previous results is priceless, the process of finding, evaluating and finally integrating other sources into one single scheme is very demanding. We proceeded iteratively, carrying out two lines of activities in parallel: on one side the collection of the needed concepts and on the other the analysis and testing of the available models in our scenario.

7 Deviations from Annex 1

There are no deviations from Annex 1.

8 Acknowledgement

The author(s) would like to thank the partners in the project for their valuable comments on previous drafts and for performing the review.

Project partners:

#	Type	Partner	Partner full name
1	SME	CMCL	Computational Modelling Cambridge Limited
2	Research	FHG	Fraunhofer Gesellschaft zur Förderung der Angewandten Forschung E.V.
3	Research	INTRA	Intrasoft International SA
4	University	UNIBO	Alma Mater Studiorum – Università di Bologna
5	University	EPFL	Ecole Polytechnique Federale de Lausanne
6	Research	UKRI	United Kingdom Research and Innovation
7	Large Industry	SISW	Siemens Industry Software NV
8	Large Industry	BOSCH	Robert Bosch GmbH
9	SME	UNR	Uniresearch B.V.
10	Research	SINTEF	SINTEF AS
11	SME	CNT	Cambridge Nanomaterials Technology LTD
12	University	UCL	University College London



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9 Table of Abbreviations

Abbreviation	Explanation
ADE	Alignment of DOME 4.0 and EMMO
API	Application Programming Interface
CORDIS	Community Research and Development Information Service
DOI	Digital Object Identifier
EMMC	European Materials Modelling Council
EMMO	Elementary Multiperspective Material Ontology
EuroSciVoc	European Science Vocabulary
EVMPPO	European Virtual MarketPlace Ontology
FAIR	Findable Accessible Interoperable Reusable
HTTP	Hypertext Transfer Protocol
IOF	Industrial Ontology Foundry
OCES	Ontology Commons EcoSystem
OWL	Web Ontology Language
RBAC	Role-Based Access Control
RDF	Resource Description Framework
RDFS	RDF Schema
REST	REpresentational State Transfer
RoMM	Review of Materials Modelling
TTL	Terse RDF Triple Language (Turtle)
VIMMP	Virtual Materials MarketPlace
W3C	World Wide Web Consortium

Appendix 1 – Relevant information models and ontologies

In Table 1 below we summarize relevant information models and ontologies, pointing out their relevance, scope, usage, language, format, license and links, to both source and documentation.

Table 1: Relevant information models and ontologies

Name	Links (webpage and/or reference)	Relevance	Scope	Usage (and development stage)	Language and format	License
VIMMP (Virtual Materials Marketplace) Ontologies	source ¹⁸ , papers ^{19,20}	Aligned with EMMO	Materials Marketplaces (Agents, services, modelling, ...)	Within the VIMMP platform	OWL; Turtle (.TTL)	LGPL v3
The International Data Spaces (IDS) Information Model	source ²¹ , doc ²²	Information model of a possible architecture	Data marketplaces and ecosystems (security, sovereignty, privacy, ...)	Used within IDS. Version 4.1.0 (being developed).	RDFS/OWL ontology	Apache License, v2.0
DAFNI (Data & Analytics Facility for National Infrastructure) Ontologies	source ²³	Uses DCAT. Alignments with DCAT-AP GeoDCAT-AP OGC EO GeoJSON-LD and NSGI-LD (geometry level) INSPIRE	Infrastructure and Cities	Spatial datasets (ongoing, customisable by user community)	Serialised as JSON-LD	Not decided yet (but open, probably CC-BY-SA 4.0).
DCAT (Data Catalog Vocabulary)	https://www.w3.org/TR/vocab-dcat-2/	Basic dataset building block. Mixes well with other W3C standards.	Interoperability between data catalogues published on the Web	Search engines: Supported by Google (search)	OWL2 ontology formalized using RDF-Schema (available as .TTL too)	Permissive, W3C license

¹⁸ <https://gitlab.com/vimmp-semantic/vimmp-ontologies>

¹⁹ [doi:10.5281/zenodo.3936795](https://doi.org/10.5281/zenodo.3936795)

²⁰ <https://doi.org/10.1007/978-3-030-68597-3>

²¹ <https://github.com/International-Data-Spaces-Association/InformationModel>

²² <https://international-data-spaces-association.github.io/InformationModel/docs/index.html#>

²³ <https://dafni.ac.uk/dafni-champions-2-2/dafni-champions-infrastructure-research-ontologies-2/>

		Very aligned with Dublin Core.				
Schema.org	https://schema.org/	Basic dataset building block. Generic schema for web metadata (discovery).	To find “things” on the web like people, places, organisations .	Recommended by Google. Sponsored by Google, Inc., Yahoo, Inc., Microsoft Corporation and Yandex. Established.	Recommended to be serialised as JSON-LD. (also used with microdata, RDFa)	CC BY-SA 3.0
PROV-O	https://www.w3.org/TR/prov-o/	Used by DCAT Extra RBAC roles.	Provenance (traceability, lineage). Attribution, inc. software agents.	Established	Turtle but easily used in JSON-LD serialisations	W3C license
CSVW (CSV on the Web)	https://www.w3.org/ns/csvw	Tabular metadata	Tabular data	Established	Turtle JSON-LD	W3C license
Verifiable Credentials Data Model 1.0	https://www.w3.org/TR/vc-data-model/	Identity, secure transactions	Security, RBAC, ecommerce	Brings together existing standards: e.g. Leverages JWT web tokens	JSON-LD	W3C license
PaasPort	source ²⁴ , paper ²⁵	Platform as a service, partially used within VIMMP too	Platform as a service	Version 1.0	OWL	Not clear, probably permissive (was part of PaasPort project, FP7-605193)
e-Class OWL	http://www.heppnetz.de/projects/eclassowl/	Research version of ECLASS (eCl@ss) a worldwide ISO/IEC-compliant data standard for goods and services	Industrial goods and services	Version 5.1.4 (Commercial ECLASS is at version 12.0)	OWL (RDF/XML)	This is an older version for research purposes (The full ECLASS is not free)

²⁴ <http://lps.csd.auth.gr/ontologies/paasport/paasport.owl>

²⁵ <http://www.semantic-web-journal.net/system/files/swj1503.pdf>

MDO (Materials Design Ontology)	source ²⁶ , doc ²⁷	Ontology based on OPTIMADE API	Solid state physics and computational materials science	Version 1.0	OWL (RDF/XML)	MIT License
Industrial Ontology Foundry (IOF) core	source ²⁸	Mid-level ontology from IOF	Manufacturing	Under development · This is version BFO-IOF-2020, new release due soon.	OWL; Turtle, owl	GPL v3.0
Good relations	source ²⁹ , doc ³⁰	Vocabulary, official e-commerce part of schema.org	E-commerce	Version 1.0. Used by search engines (e.g., Google, Yahoo!).	OWL (RDF/XML)	CC BY 3.0

²⁶ <https://github.com/LiUSemWeb/Materials-Design-Ontology>

²⁷ <https://w3id.org/mdo/full/1.0/>

²⁸ <https://github.com/NCOR-US/IOF-BFO/tree/IOF-Core-2020>

²⁹ <http://purl.org/goodrelations/v1.owl>

³⁰ <http://www.heppnetz.de/ontologies/goodrelations/v1.html>

Appendix 2 – Relevant digital marketplace initiatives

In Table 2 below we summarize relevant digital marketplace initiatives, pointing out their scope, interface, access and the links, both to the marketplace itself and to references.

Table 2: Relevant digital marketplace initiatives

Name and acronym	Link to the marketplace itself (and reference)	Scope	Interface	How to access ³¹ (registration or fee needed)
EOSC (European Open Science Cloud) Portal Catalogue and Marketplace	https://marketplace.eosc-portal.eu/	Multiple domains (data and tools)	UI	Registration
Materials Commons 2.0	https://materialscommons.org/	Material science, to collaborate, store and publish (data, workflow)	REST API, UI and others	Registration
The Materials Project	https://materialsproject.org/	Electronic structure (data, analysis tools)	REST API and UI	Registration
Materials Cloud	https://www.materialscloud.org/ (https://www.nature.com/articles/s41597-020-00637-5)	Resources in computational materials science	REST API	Open (no registration or fee)
VIMMP (Virtual Materials Marketplace)	https://vimmp.osth.us.com/vimmp/search	Materials modelling, two-sided marketplace	REST API and UI	Registration
DAFNI (Data & Analytics Facility for National Infrastructure)	https://dafni.ac.uk/	Infrastructure and Cities (data and tools)	REST API and UI	Restricted
MarketPlace	https://www.materials-marketplace.eu/	Materials modelling	REST API and UI	Restricted
Market4.0	https://platform.market40.eu/	Production equipment and service marketplace	APIs	Registration (Open access to the catalogue)

³¹ For full functionality (as opposed to partial functionality, as browsing of some data, that is often openly available).

Appendix 3 – Other relevant assets and projects

In Table 3 below we summarize other relevant assets and projects, pointing out their type, scope, status, relevance and the links, both to the asset/project itself and to references.

Table 3: Other relevant assets and projects

Name and acronym	Link to the asset/project itself (and reference)	What it is	Scope	Status	Relevance / Notes
GAIA-X	https://www.data-infrastructure.eu/GAIA/Navigation/EN/Home/home.html (e.g., see the Technical architecture)	European data infrastructure	Various themes, including “Industry 4.0/SME”	Ongoing project	Model for data assets. Self-descriptions are key.
AARC	https://aarc-project.eu/architecture/	Set of software building blocks for international research collaborations	Interoperability for Authorization and Authentication (AAI)	Completed projects (AARC1 and 2). Used in scientific collaborations as LIGO, LHC grid	
Data Europa	https://data.europa.eu/en	EU Portal for data	Public sector	Running platform	Uses DCAT-AP, DC, ADMS (Asset Description Metadata Schema) ³² Evaluates catalogues’ FAIRness.
DataPorts	https://dataports-project.eu/ (https://platform.dataports-project.eu/docs/semantic/ and their D3.2)	Platform for seaport logistics	Seaport logistics	Ongoing project	Topic overlap with DOME 4.0 UseCase #1
i3-Market	https://www.i3-market.eu/	“Amazon-like” connection between marketplaces	General, but attention given to industrial data	Ongoing project	
re3data	https://www.re3data.org/	Global registry of research data repositories	Multiple disciplines	Running platform	

³² <https://www.w3.org/TR/vocab-adms/>

Appendix 4 – Example

In this Appendix we give some examples of individuals³³, to clarify the usage of concepts introduced in Section 0. This and similar information is used by the semantic broker when a search is performed on DOME 4.0 user interface. We note in passing that the two platforms in this example are directly involved in DOME 4.0 showcases (cf. DOME 4.0 Deliverable D4.1).

```

@prefix dome-core: <https://dome40.eu/semantics/dome4.0_core#> . # non-resolvable URI
@prefix pl: <https://dome40.eu/semantics/scenario/platforms#> . # non-resolvable URI

@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix skos: <http://www.w3.org/2004/02/skos/core#> .
@prefix xs: <http://www.w3.org/2001/XMLSchema#> .

pl:CHEMEO a dome-core:platform ;
  dome-core:has_platform_topic dome-core:NATURAL_SCIENCES ;
  dome-core:has_platform_name "Chemeo"^^xs:string ;
  dome-core:has_platform_url_home "https://www.chemeo.com/"^^xs:anyURI ;
  dome-core:has_platform_url_query_api "/api/discover/results/CHEMEO?search_string="^^xs:anyURI ;
  dome-core:offers dome-core:MATERIAL_PROPERTY ;
  dome-core:has_some_free_product true ;
  dome-core:has_platform_type dome-core:DATA_PROVIDER ;
  dome-core:has_platform_url_api_documentation "https://www.chemeo.com/api/v1/swagger.json"^^xs:anyURI .

pl:MATERIALSPROJECT a dome-core:platform ;
  dome-core:has_platform_topic dome-core:NATURAL_SCIENCES ;
  dome-core:has_platform_name "Materials Project"^^xs:string ;
  dome-core:has_platform_url_home "https://materialsproject.org/"^^xs:anyURI ;
  dome-core:has_platform_url_query_api "/api/discover/results/MATERIALS_PROJECT?search_string="^^xs:anyURI ;
  dome-core:offers dome-core:MODELLING_DATA ;
  dome-core:has_some_free_product true ;
  dome-core:has_platform_type dome-core:CONSUMER , dome-core:DATA_PROVIDER , dome-core:INTERACTIVE_APP_PROVIDER ;
  dome-core:conforms_to dome-core:OPTIMADE_API_SPECIFICATION .

pl:EXAMPLE_DOME_SUBSCRIPTION_BY_USAGE_CHEMEO_MATERIALSPROJECT a dome-core:offering_by_usage ;
  dome-core:has_offering_name "(Example) DOME 4.0 Subscription by usage to MaterialsProject and Chemeo"^^xs:string ;
  dome-core:has_offering_description ""This subscription by usage gives access to all products on the MaterialsProject and Chemeo platforms. Pricing is done by number of downloaded datasets.""^^xs:string ;
  dome-core:has_offering_one_off_cost "30.00"^^xs:decimal ;
  dome-core:has_offering_periodicity "1 month"^^xs:string ;
  dome-core:has_offering_periodic_cost "5.00"^^xs:decimal ;
  dome-core:includes_platform pl:MATERIALSPROJECT ;
  dome-core:includes_platform pl:CHEMEO ;
  dome-core:has_offering_number_of_free_periods "0.25"^^xs:decimal ;
  dome-core:has_offering_pricing_unit "Number of downloaded datasets"^^xs:string ;
  dome-core:has_cost_per_unit "0.50"^^xs:decimal .

...

```

Figure 5: Extract of `platforms.ttl` file, showing instances of the Ecosystem Ontology concepts. The full file is available with the ontology source files.

³³ Extracts are taken from the “platforms.ttl” file (version 1.0.0), available with the ontology's source.