ONTO COMMONS
ONTOLOGY-DRIVEN DATA DOCUMENTATION FOR INDUSTRY COMMONS

# *OntoCommons* Project

## OntoCommons Ecosystem (OCES)

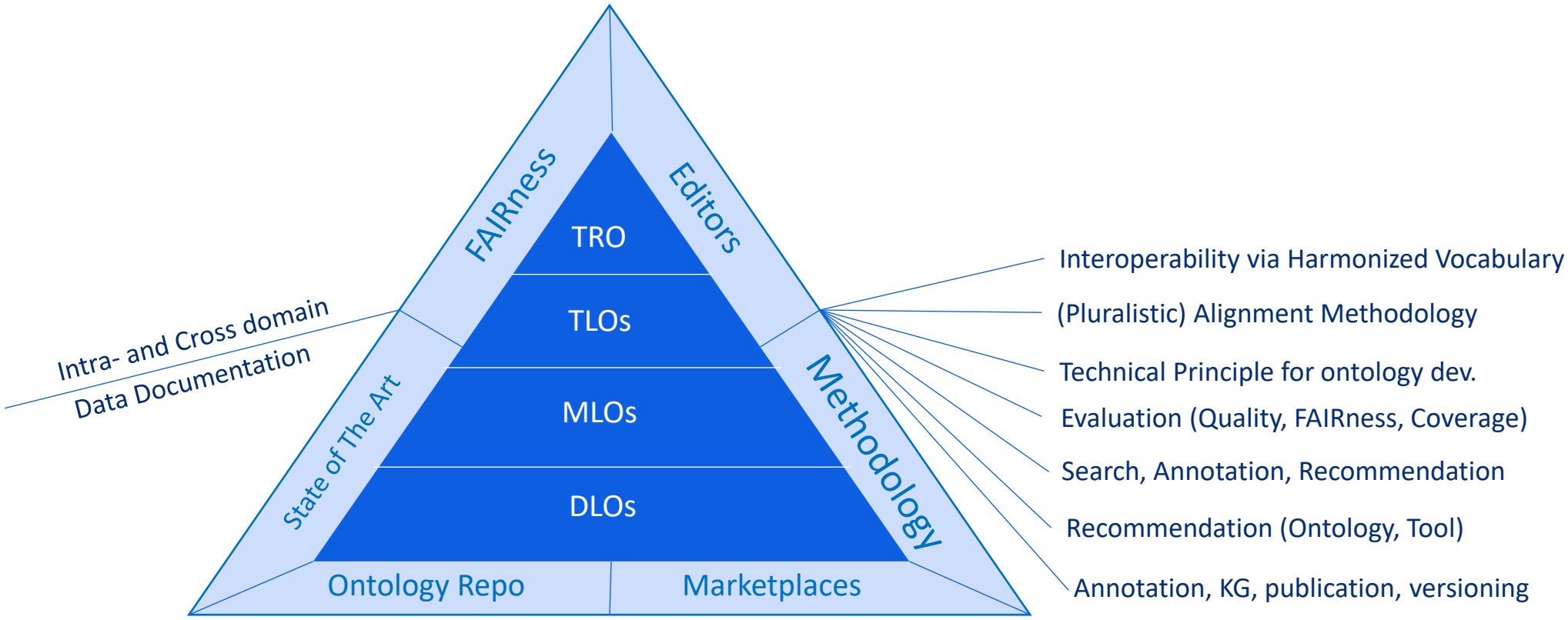
Arkopaul Sarkar (ENIT)

*OntoCommons Member and WP3 Lead*

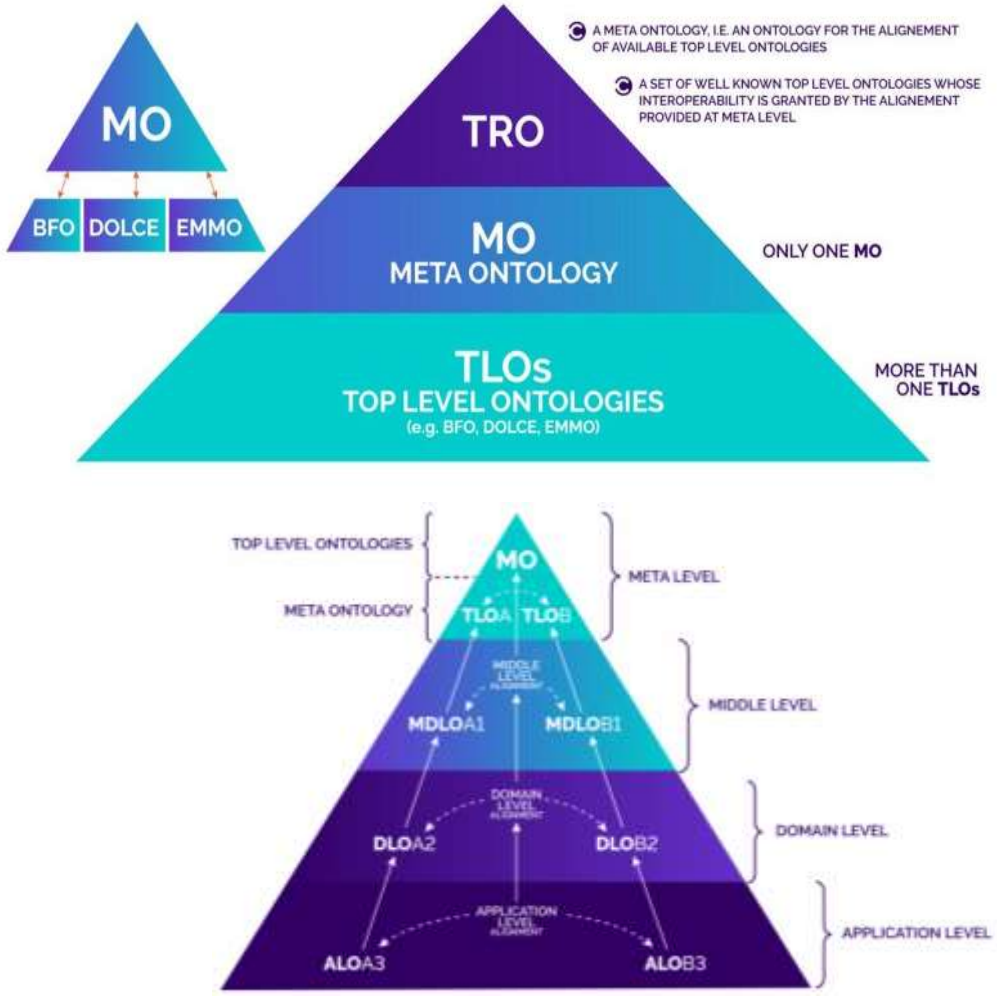
OntoComm ons “Ontology-driven data documentation for Industry Commons” has received funding from the European Union’s Horizon Programme call H2020 -NMBP-TO-IND-2020-singlestage, Grant Agreement number 958371

# The most tangible outcome – OntoCommons Ecosystem

- OCES is a combination of fully harmonized ontology artifacts (from top to domain) and associated tools and methodologies for building upon existing and creating future ontologies. The complementary components of **OCES therefore provide a complete solution for data documentation in the NMBP domains.**



# Ontologies harmonisation

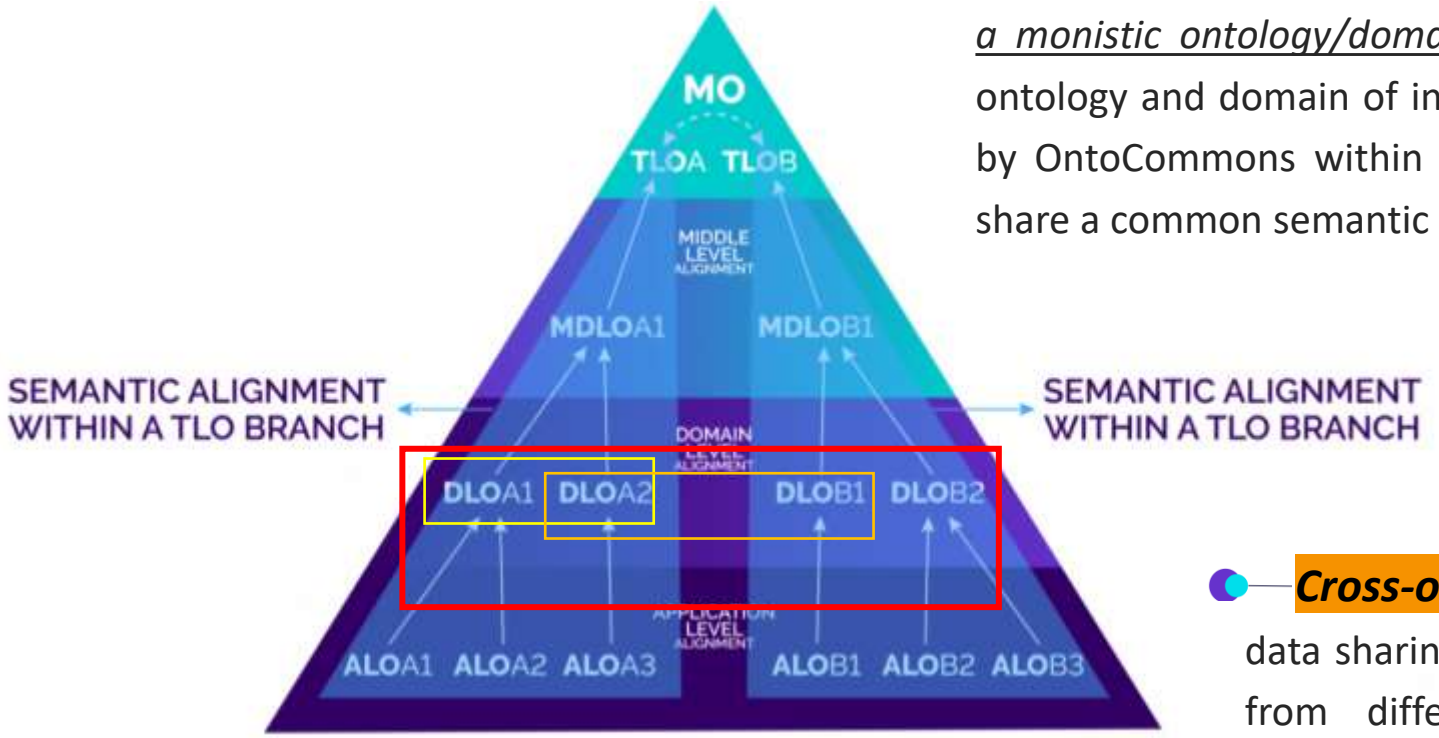



***OntoCommons will provide harmonisation between ontologies, through Top Reference Ontology through a multilevel alignement:***

- ***Syntactic*** alignment (OWL, FOL, etc.) for all the ontologies that will be part of the OES.
- **Terminological** alignment enabling a minimum taxonomical interoperability between ontologies, by pasting a sub-branch of one ontology under another ontology.
- **Semantic** alignment will be targeted primarily by OntoCommons only within TLO branches,.
- **Formatting** alignment including e.g. labelling of classes, the definition of terms and the annotations.

**The OCES will adopt a pluralist approach for the ontological representation of a domain of interest, meaning that more than one upper ontology may be adopted.**

# Intra and Cross-ontology interoperability




- ***Intra-ontology interoperability*** **:** The capability to enable data sharing between a single semantic representation of data from TLO to ALO coming from *a monistic ontology/domain approach* (one-to-one exclusive relation between ontology and domain of interest). This type of interoperability will be addressed by OntoCommons within a TLO ontology branch whose lower ontology levels share a common semantic framework.

- ***Cross-ontology interoperability*** the capability to enable data sharing between different semantic representations of data from different TLOs branches coming from a *pluralistic ontology/domain approach*.

# Status of TRO

- BFO to DOLCE and vice versa is already published (v0.3).
- Now working on DOLCE – EMMO mappings.

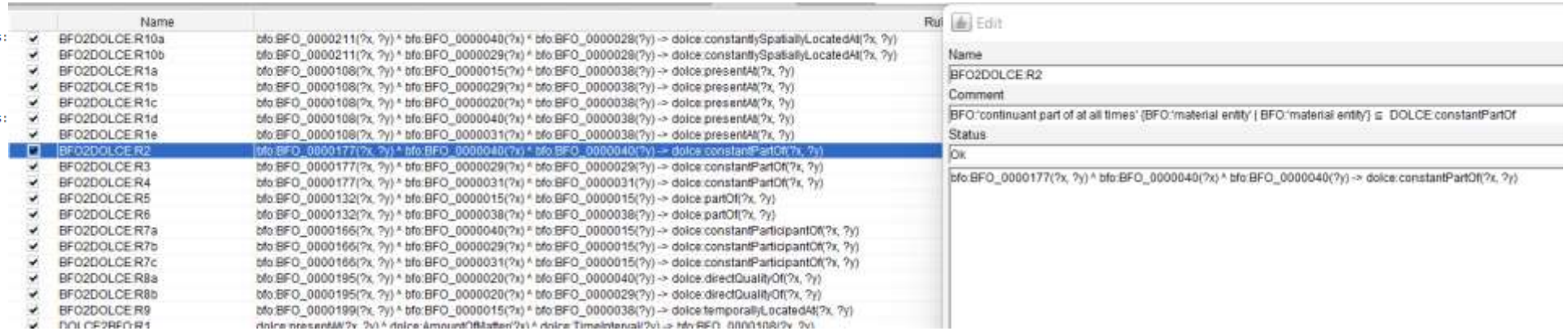
```
--
###  http://purl.obolibrary.org/obo/BFO_0000028
<http://purl.obolibrary.org/obo/BFO_0000028> rdfs:subClassOf <http://www.loa.istc.cnr.it/dolce/dolce-owl/DOLCEbasic#SpaceRegion> .


###  http://purl.obolibrary.org/obo/BFO_0000029
<http://purl.obolibrary.org/obo/BFO_0000029> rdfs:subClassOf <http://www.loa.istc.cnr.it/dolce/dolce-owl/DOLCEbasic#Feature> .


###  http://purl.obolibrary.org/obo/BFO_0000031
<http://purl.obolibrary.org/obo/BFO_0000031> rdfs:subClassOf <http://www.loa.istc.cnr.it/dolce/dolce-owl/DOLCEbasic#NonPhysicalEndurant> .


###  http://purl.obolibrary.org/obo/BFO_0000038
<http://purl.obolibrary.org/obo/BFO_0000038> rdfs:


###  http://purl.obolibrary.org/obo/BFO_0000040
<http://purl.obolibrary.org/obo/BFO_0000040> rdfs:
```




### 3.4.1 continuantPartOf

$\mathbf{t_{db}28}$ $\mathfrak{D} \cup \mathfrak{M}_{db} \vdash x ::_I \texttt{idcnt} \rightarrow \texttt{cP}(x,x,t)$ $(\mathbf{a_b}27)$

*Proof.* According to $(\mathbf{d_{db}}10)$ and $(\mathbf{d_{db}}11)$ if $x$ is a material entity, a site, or a continuant fiat boundary such that $\mathrm{PRE}(x,t)$ holds then the thesis follows from $(\mathbf{a_d}17)$. According to $(\mathbf{d_{db}}12)$, if $x$ is a BFO spatial region then it is a DOLCE space region; the thesis follows from $(\mathbf{a_d}5)$. □

$\mathbf{t_{db}29}$ $\mathfrak{D} \cup \mathfrak{M}_{db} \vdash \texttt{cP}(x,y,t) \wedge \texttt{cP}(y,z,t') \wedge \texttt{tmP}(t,t') \rightarrow \texttt{cP}(x,z,t)$ $(\mathbf{a_b}28)$

*Proof.* If $x$ is an endurant then the thesis follows from $(\mathbf{a_d}16)$ and $(\mathbf{a_d}18)$. If $x$ is a space region the thesis follows from $(\mathbf{a_d}7)$. If $x$ is a quality the thesis follows from $(\mathbf{a_d}16)$, $(\mathbf{a_d}18)$, $(\mathbf{a_d}34)$ and $(\mathbf{a_d}36)$. □

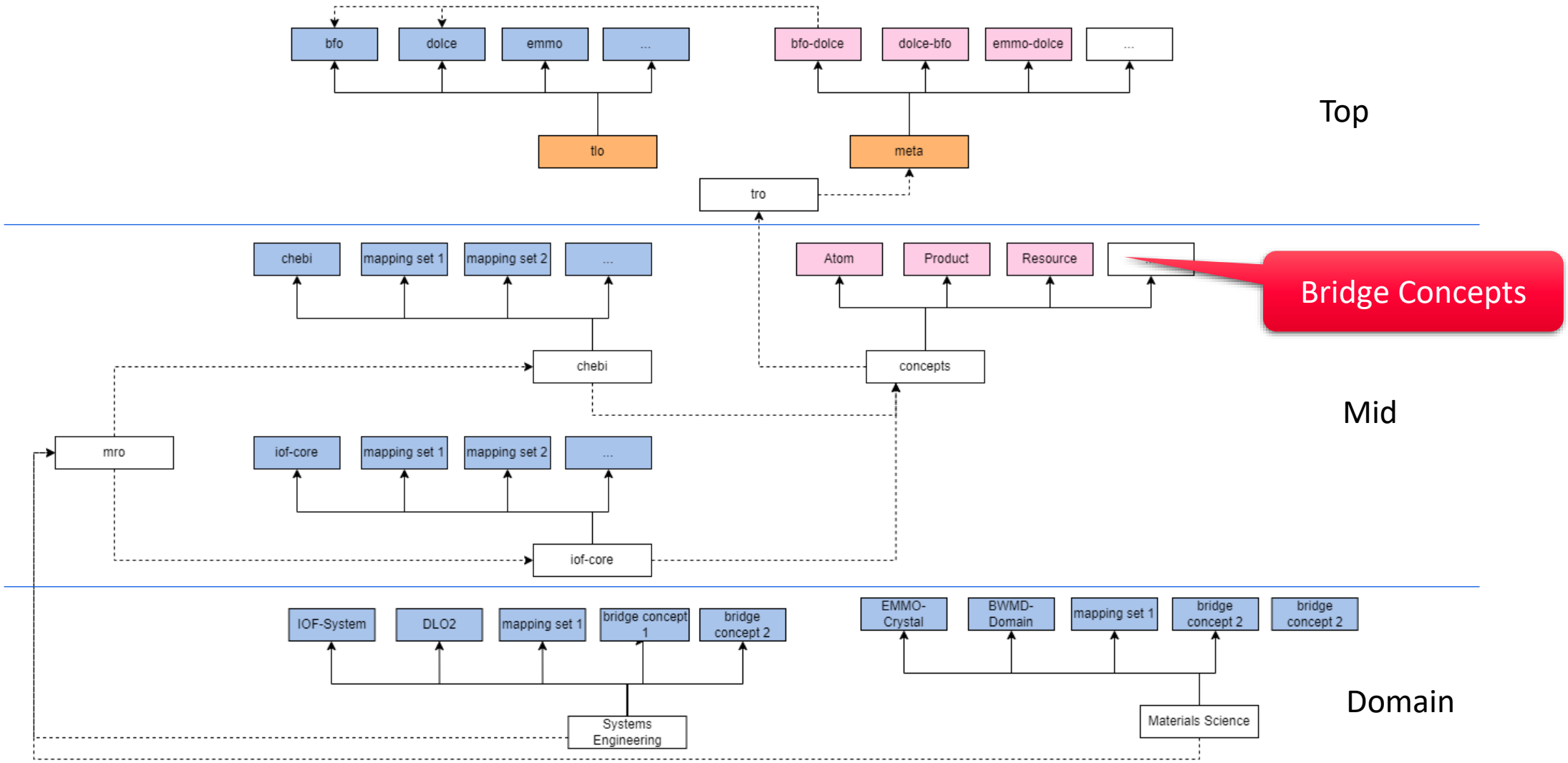
$\mathbf{t_{db}30}$ $\mathfrak{D} \cup \mathfrak{M}_{db} \vdash \texttt{cP}(x,y,t) \wedge x \neq y \rightarrow \exists z(\texttt{cP}(z,y,t) \wedge z \neq y \wedge \neg \texttt{cO}(z,x,t))$ $(\mathbf{a_b}29)$

*Proof.* If $x$ is an endurant the thesis (mainly) follows from $(\mathbf{a_d}19)$. If $x$ is a space regions the thesis (mainly) follows from $(\mathbf{a_d}8)$. If $x$ is a quality the thesis (mainly) follows from $(\mathbf{a_d}19)$, $(\mathbf{a_d}34)$, and $(\mathbf{a_d}36)$. □

$\mathbf{t_{db}31}$ $\mathfrak{D} \cup \mathfrak{M}_{db} \vdash \texttt{cO}(x,y,t) \rightarrow \exists z(\forall w(\texttt{cP}(w,z,t) \leftrightarrow \texttt{cP}(w,x,t) \wedge \texttt{cP}(w,y,t)))$ $(\mathbf{a_b}30)$

*Proof.* If $x$ is an endurant the thesis (mainly) follows from $(\mathbf{a_d}21)$. If $x$ is a space regions the thesis (mainly) follows from $(\mathbf{a_d}10)$. If $x$ is a quality the thesis (mainly) follows from $(\mathbf{a_d}21)$, $(\mathbf{a_d}34)$, and $(\mathbf{a_d}36)$. □

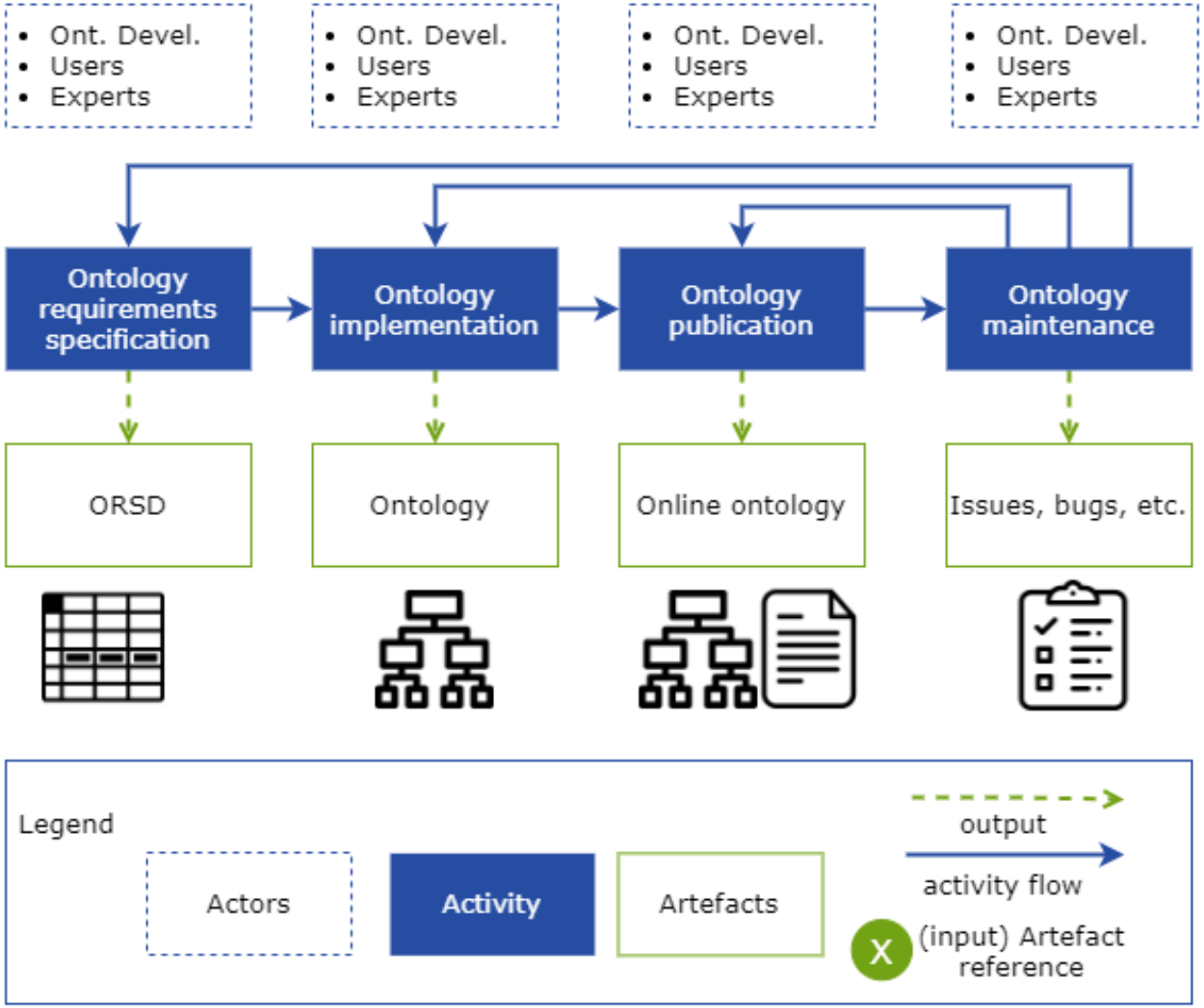
# OCES Ontology Stack



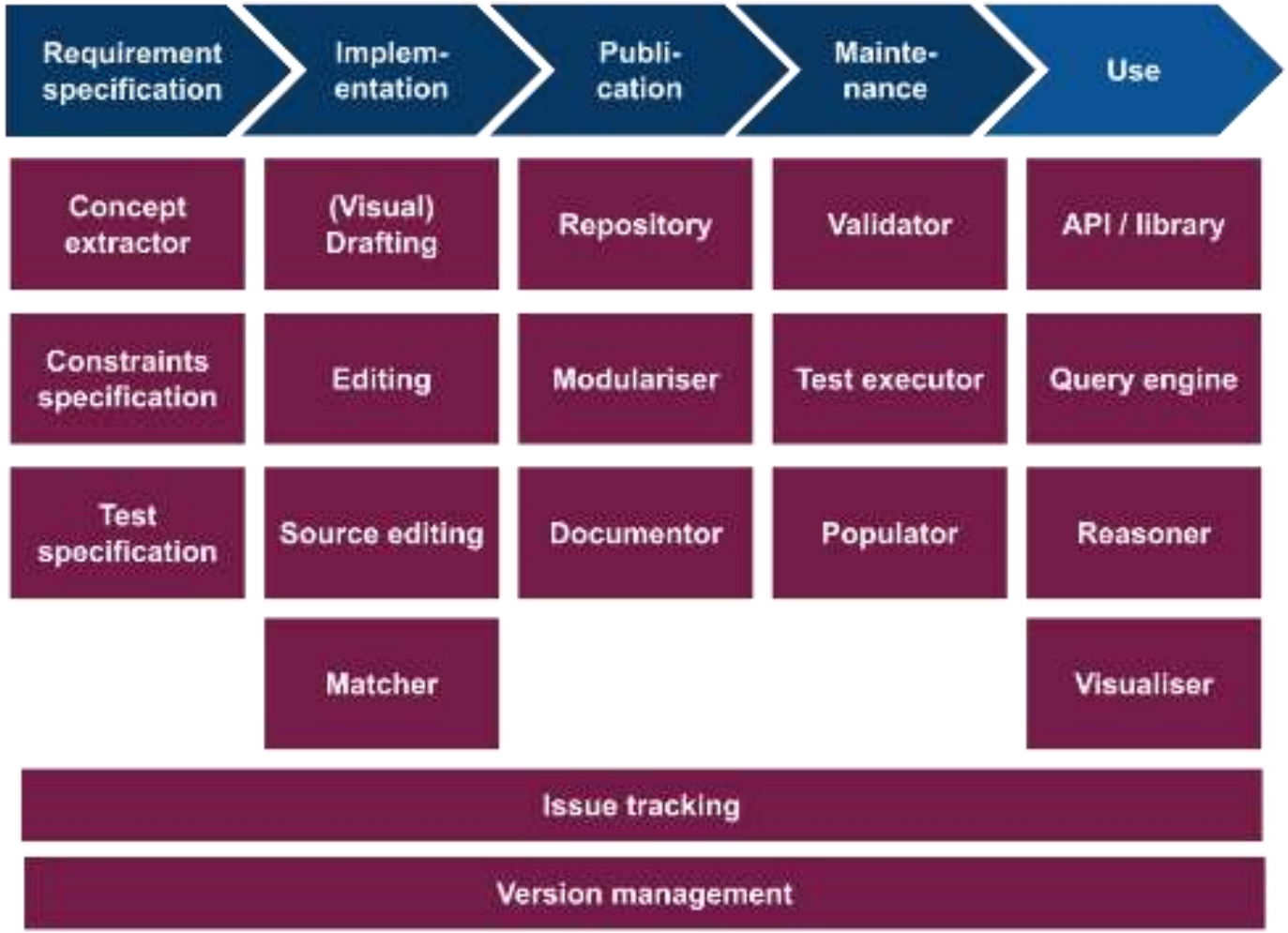
# Bridge concept

- **Standalone ontology entities** with an extensive documentation: a practical dictionary tailored for ontology-implementation.
  - Explicitly connected to the core Knowledge Domain Resources and Standards but still separated.
- They are akin to **universal adapters/converters**, supporting (and facilitating) strong semantic alignments among a plurality of ontologies.
  - Interoperability for data exchange
- (Vertical) Mediated connection result from multiple connections. Reasoning spreads downwards (in general from higher to lower-level ontologies).
- (Horizontal) Data sharing is established
- Secondary benefits: Disambiguity, Modularisation

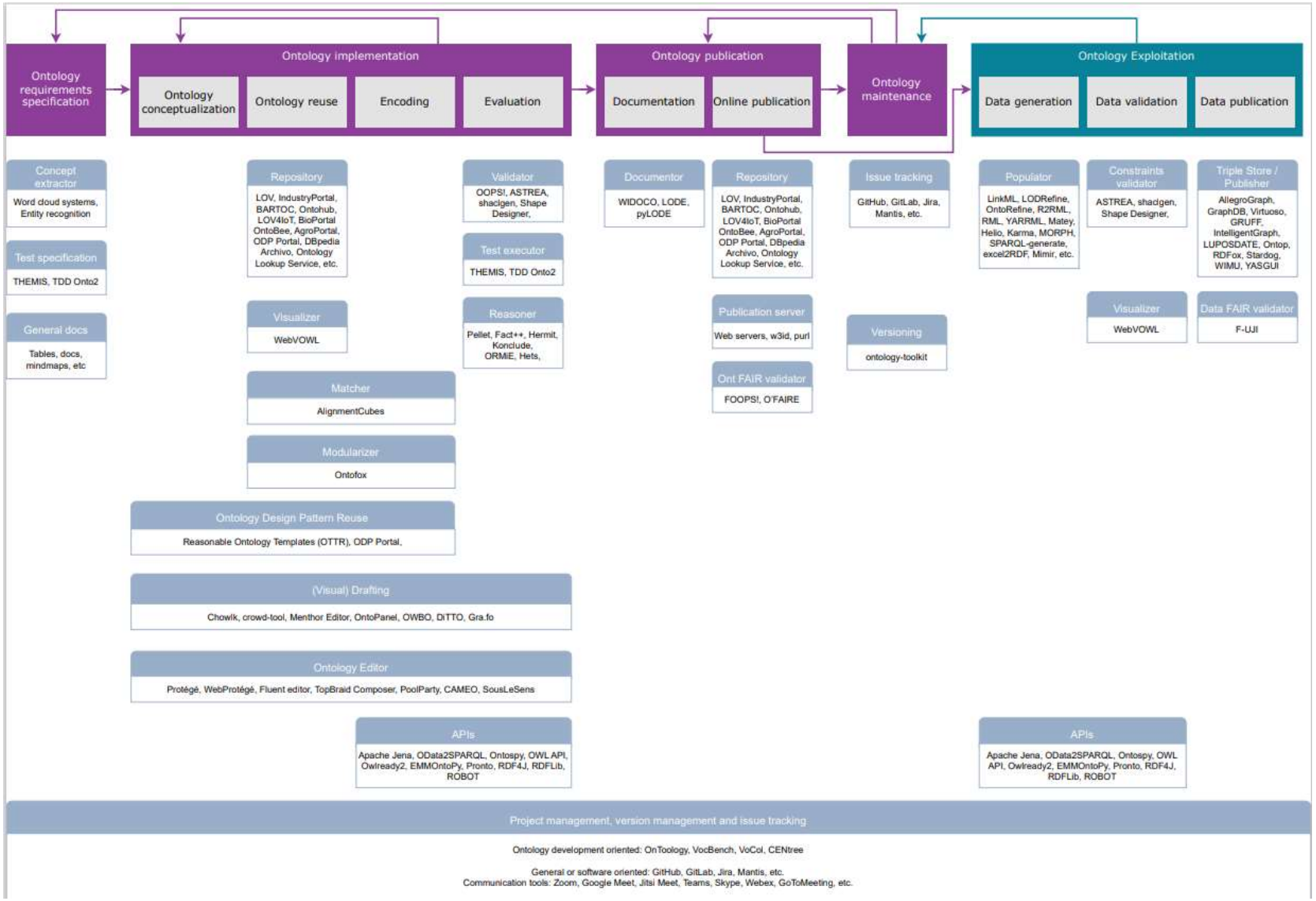
# LOT Methodology



# Components of the ontology ecosystem toolkit



# Tools


Ontology requirements specification
Ontology implementation
Ontology conceptualization
Ontology reuse
Encoding
Evaluation
Ontology publication
Documentation
Online publication
Ontology maintenance
Ontology Exploitation
Data generation
Data validation
Data publication
Concept extractor
Word cloud systems, Entity recognition
Test specification
THEMIS, TDD Onto2
General docs
Tables, docs, mindmaps, etc
Repository
LOV, IndustryPortal, BARTOC, Ontohub, LOV4IoT, BioPortal OntoBee, AgroPortal, ODP Portal, DBpedia Archivo, Ontology Lookup Service, etc.
Visualizer
WebVOWL
Validator
OOPS!, ASTREA, shaclgen, Shape Designer,
Test executor
THEMIS, TDD Onto2
Reasoner
Pellet, Fact++, Hermit, Konclude, ORME, Hets,
Matcher
AlignmentCubes
Modularizer
Ontofox
Ontology Design Pattern Reuse
Reasonable Ontology Templates (OTTR), ODP Portal,
(Visual) Drafting
Chowlk, crowd-tool, Menthor Editor, OntoPanel, OWBO, DiTTO, Gra.fo
Ontology Editor
Protégé, WebProtégé, Fluent editor, TopBraid Composer, PoolParty, CAMEO, SousLeSens
APIs
Apache Jena, OData2SPARQL, Ontospy, OWL API, Owlready2, EMMOntoPy, Pronto, RDF4J, RDFLib, ROBOT
Documentor
WIDOCO, LODE, pyLODE
Repository
LOV, IndustryPortal, BARTOC, Ontohub, LOV4IoT, BioPortal OntoBee, AgroPortal, ODP Portal, DBpedia Archivo, Ontology Lookup Service, etc.
Publication server
Web servers, w3id, purl
Ont FAIR validator
FOOPS!, O'FAIRE
Issue tracking
GitHub, GitLab, Jira, Mantis, etc.
Versioning
ontology-toolkit
APIs
Apache Jena, OData2SPARQL, Ontospy, OWL API, Owlready2, EMMOntoPy, Pronto, RDF4J, RDFLib, ROBOT
Populator
LinkML, LODRefine, OntoRefine, R2RML, RML, YARRRML, Matey, Helio, Karma, MORPH, SPARQL-generate, excel2RDF, Mimir, etc.
Constraints validator
ASTREA, shaclgen, Shape Designer,
Visualizer
WebVOWL
Triple Store / Publisher
AllegroGraph, GraphDB, Virtuoso, GRUFF, IntelligentGraph, LUPOSDATE, Ontop, RDFox, Stardog, WIMU, YASGUI
Data FAIR validator
F-UJI
Project management, version management and issue tracking
Ontology development oriented: OnToology, VocBench, VoCol, CENtree
General or software oriented: GitHub, GitLab, Jira, Mantis, etc.
Communication tools: Zoom, Google Meet, Jitsi Meet, Teams, Skype, Webex, GoToMeeting, etc.

# Ontology Encoding (OCES Technical Principle)

- IRI Convention
  - OCIRI Grammar (based on RFC3987) –separate for TLO, MLO, DLO
  - Permanent host resolver (purl, w3id, doi, ARK)
  - Opaque identifier Scheme

**A class 'Plastic' in a domain ontology called 'plastonto'**

**http://purl.ontocommons.eu/ontology/dlo/srao-0000211/plastonto#oxcy4f**

- Metadata Convention
  - Common set of annotation properties for
    - Ontology metadata, Term metadata, Mapping metadata (SSSOM)
    - Based on MOD, OMV, DC, IOF-av, EMMO-av, FIBO-av
- Language and expressivity, Reasoner and prover, Serialisation format, Versioning scheme, Development management and issue tracking

# Bridge Concept Template

## ONTOCOMMONS BRIDGE-CONCEPT

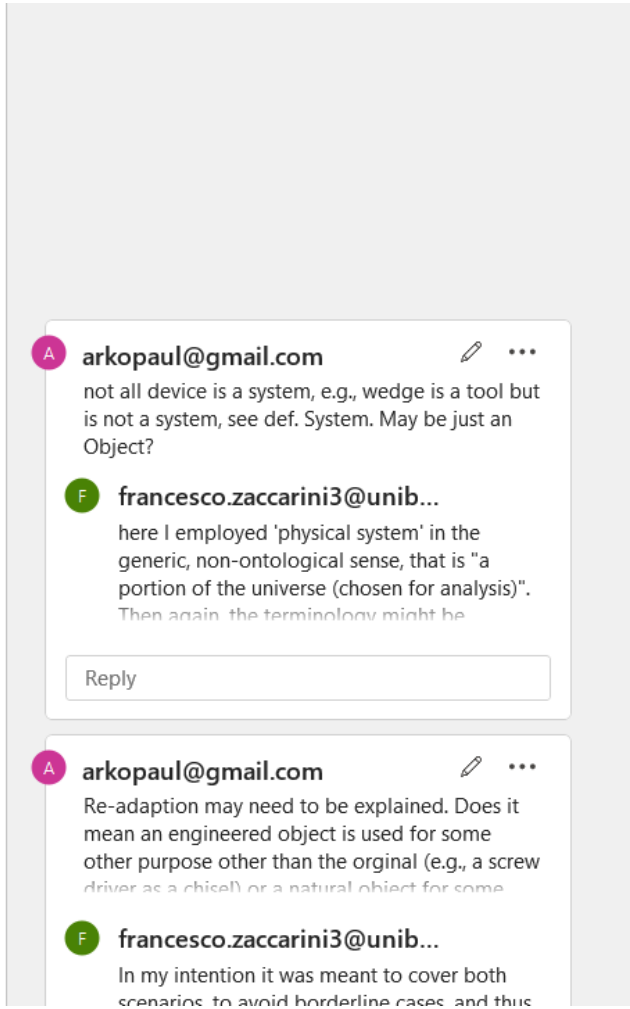
## MATERIAL DEVICE

**GENERAL CONCEPT INFO:**

| | |
|---|---|
| **IRI:** | *Suggested entity new IRI.* |
| **OWL Type:** | *Class* |
| **Concept Elucidation:** | A Device is a physical entity which is engineered to the end of completing a specific type of tasks, or to have a particular set of properties which allows them to perform certain functions under a predetermined (generic, or non-generic yet well-defined) range of scenarios.<br>Devices can be either disposable or meant for repeated/prolonged use, and they can either use a source of energy as one of the inputs for the completion of the relevant task or not.<br>Infrastructures can be considered Devices only if the infrastructure itself is pivotal in the completion of the tasks/to perform certain functions, and the relevant tasks/functions are not bound to a specific location.<br><br>Domain: Industry and Manufacturing / Empirical Sciences - Materials Science. |
| **Labels:** | *Labels used to address the concept, ordered as:*<br>*skos:prefLabel: Device*<br>*skos:altLabel: Tool (Broad)*<br>*skos:hiddenLabel: Instrument* |

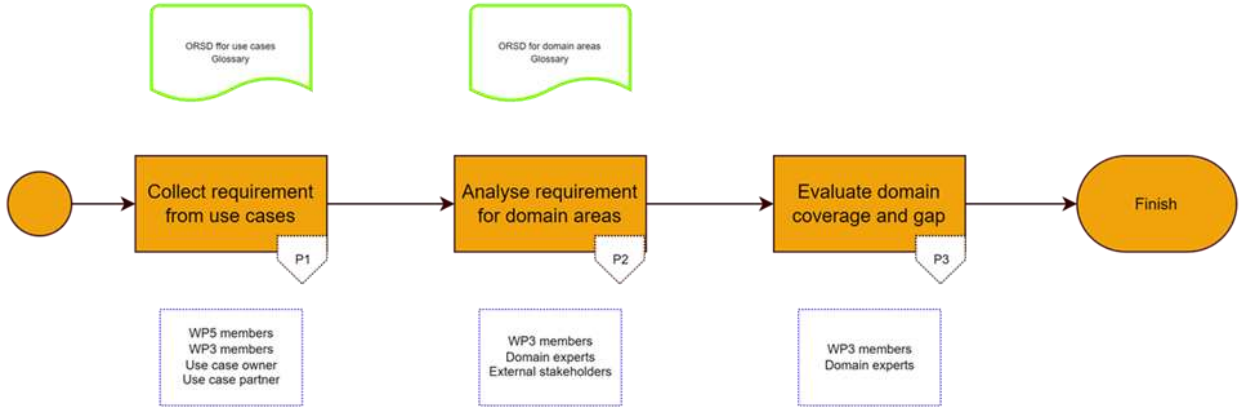
**KNOWLEDGE DOMAIN RESOURCES:**

| | |
|---|---|
| **Related Domain Resources:** | -*Wikipedia:* "a device is usually a constructed tool"; "a tool is an object that can extend an individual's ability to modify features of the surrounding environment. Although many animals use simple tools, only human beings, whose use of stone tools dates |




https://github.com/OntoCommons/OntologyFramework/blob/dev/bridge-concept-template.md

# Requirement Engineering
## (methodology, Competency Questions, ORSD)

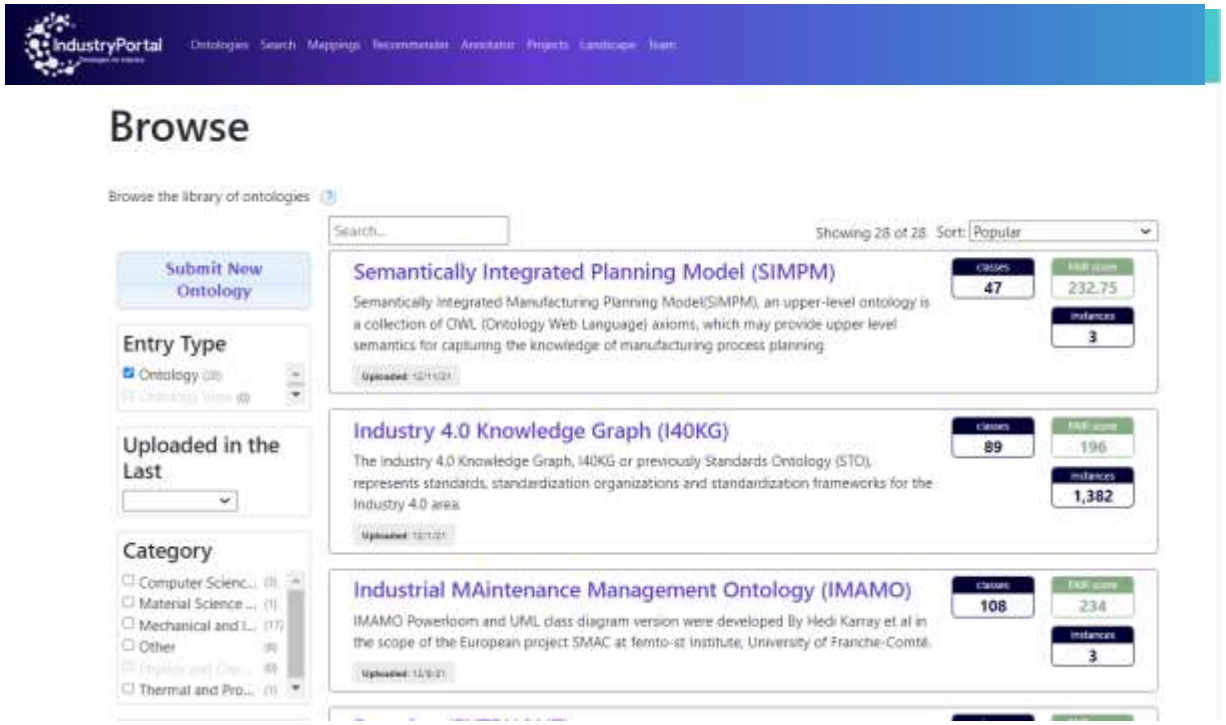


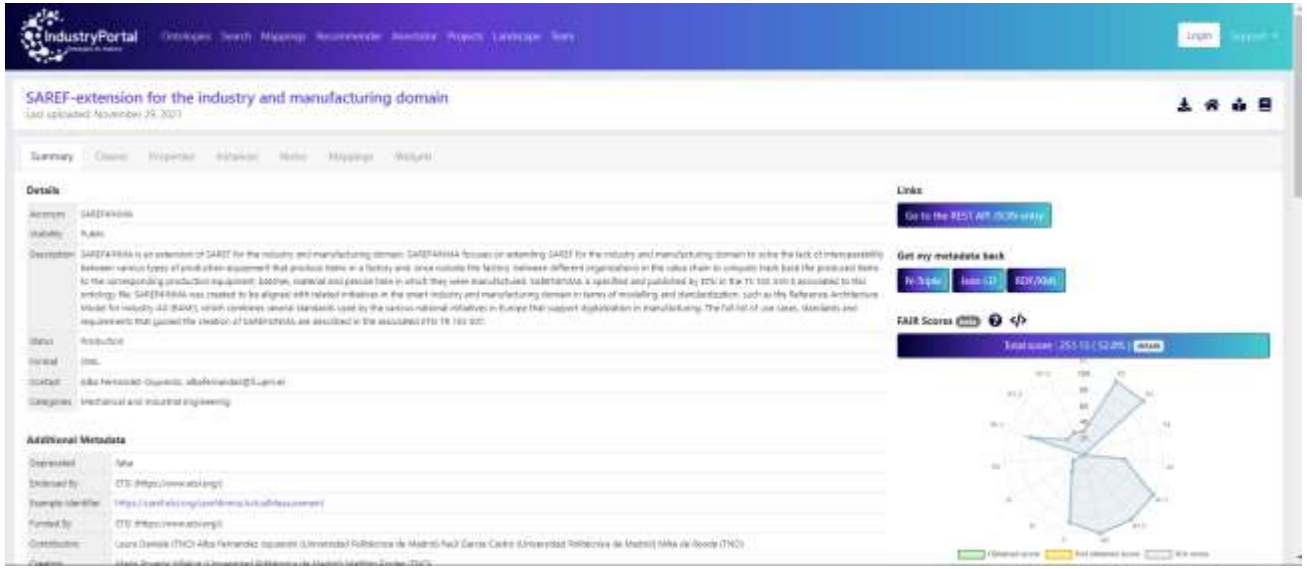

| Identifier (domain+id) | Sprint | Competency Question / Natural language sentence (fact) | Answer | Status (Proposed, Accepted, Rejected, Pending, Deprecated) |
|---|---|---|---|---|
| UC1-1 | UC interview | What are the types of resource? | Human resource, intangible resource, material resource | Accepted |
| UC1-2 | UC interview | What are the types of manufactring ressource? | Equipment, facilities | Accepted |
| UC1-3 | UC interview | What are the types of equipment? | Drilling adapter, drilling template, measuring equipment, robot, fastener, wedge | Accepted |
| UC1-4 | UC interview | What are the types of materials? | Manufacturing material, raw material, assembly | Accepted |
| UC1-5 | UC interview | What are the component of an assembly? | None. | Accepted |
| UC1-6 | UC interview | What are the types of assembly? | Front fuselage, rear fuselage | Accepted |
| UC1-7 | UC interview | What are the types of part? | Buttstrap, fastener, frame, stabiliser, stringer | Accepted |
| UC1-8 | UC interview | What are the functions for different resources? | | Accepted |
| UC1-9 | UC interview | What are the qualities of different resources? | | Accepted |
| UC1-10 | UC interview | What are the qualities of different materials? | | Accepted |
| UC1-11 | UC interview | What are the qualities of different processes? | | Accepted |
| UC1-12 | UC interview | What are the types of processes? | Boring, cleaning, deburring, drilling, fastening, fixing, insert, inspection, installation | Accepted |
| UC1-13 | UC interview | What are the functions that are realized by different processes? | | Accepted |
| UC1-14 | UC interview | What are the required ressources of different processes? | | Accepted |
| UC1-15 | UC interview | What are the required materials of different processes? | | Accepted |
| UC1-16 | UC interview | What are the information for a system requirement? | Design criteria, design rule, TLR | Accepted |
| UC1-17 | UC interview | What are the types of system model? | | Accepted |
| UC1-18 | UC interview | What are the component of a system model? | | Accepted |
| UC1-19 | UC interview | What are the sub-processes of a design process? | | Accepted |
| UC1-20 | UC interview | What are the information for a process plan? | | Accepted |
| UC1-21 | UC interview | What are the information for system design? | | Accepted |

| Ontology Requirements Specification Document | |
|---|---|
| 1 | **Purpose (mandatory)** |
| | The use case aims to demonstrate:<br>- decreased development time via automatized decision making and improved re-usability,<br>- improved reliability via traceability,<br>- improved communication between product, assembly and industrial system experts via data integration and increased domain knowledge interoperability. |
| 2 | **Scope (mandatory)** |
| | Increase the interoperability and improve the communication between aircraft design, assembly design and the industrial system design |
| 3 | **Implementation Language (optional)** |
| | |
| 4 | **Intended End-Users (optional)** |
| | 1) Knowledge scientist<br>2) System engineering expert<br>3) Assembly process engineer<br>4) Simulation engineer |
| 5 | **Intended Uses** |
| | The system is expected to support decision-making during aircraft industrial system design. Some expected benefits include:<br>1) Predict behavior, explore architectural alternatives early in the development process, and perform trade studies to assess which design choices make the most sense for manufacturing performance.<br>2) Develop a cognitive twin based on captured domain knowledge, models and simulations.<br>3) Perform a Business transformation that includes new organizations and new roles to develop the models and to perform manufacturing engineering activities. |
| 6 | **Ontology Requirements** |
| | 1. **Non-Functional Requirements** |
| | This use case will be based on the output of a relevant project (QU4LITY) pilot. Another objective is to improve the interoperability by aligning the application ontology to the top level ontology or top reference ontology which are expected output of OntoCommons. |
| | 1. **Functional Requirements: Lists or tables of requirements written as Competency Questions and sentences** |
| | |
| 7 | **Pre-Glossary of Terms (optional)** |
| | 1. **Terms from Competency Questions** |
| | |
| | 1. **Terms from Answers** |
| | |
| | 1. **Objects** |
| | |

Deliverable D3.4 contains detailed requirement for NMBP domains based on 11 use cases and stakeholder's input

# IndustryPortal http://industryportal.space/



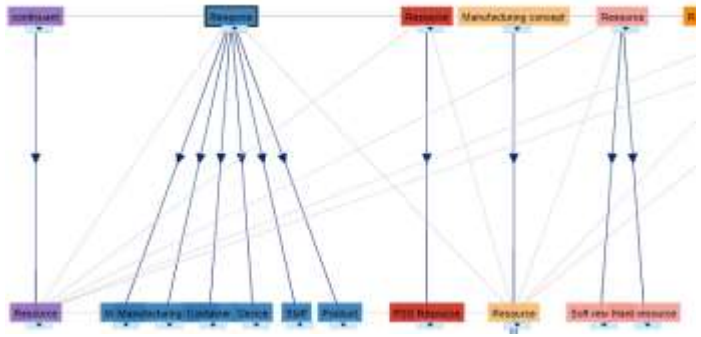

## Ontology Recommender

Get recommendations for the most relevant ontologies based on an excerpt from a biomedical text or a list of keywords

What is the **function** or **capability** of **equipment**?

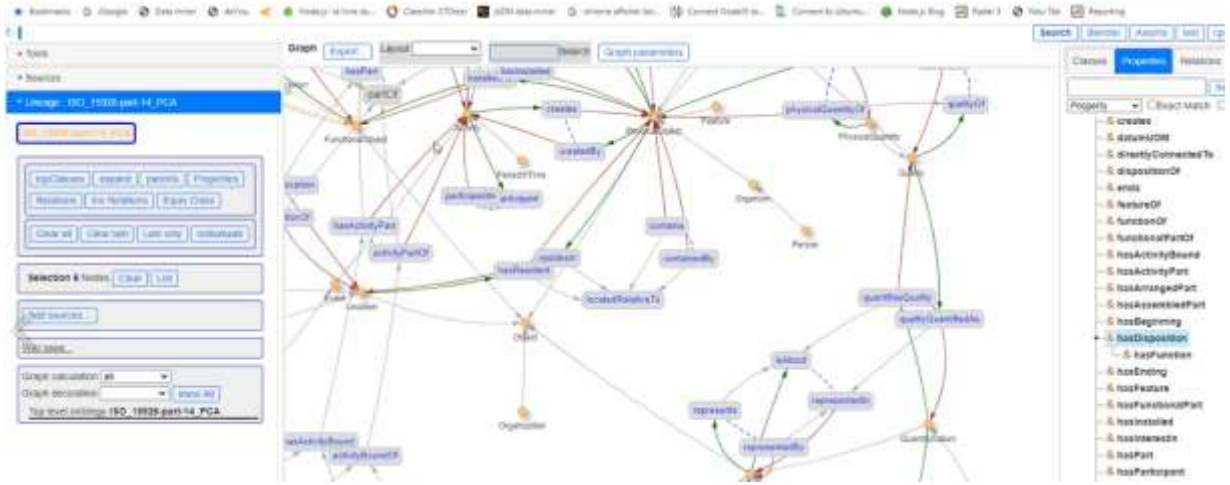
Recommended ontologies

| POS. | ONTOLOGY | FINAL SCORE | COVERAGE SCORE | ACCEPTANCE SCORE | DETAIL SCORE | SPECIALIZATI |
|---|---|---|---|---|---|---|
| 1 | MSDL | 73.3 | 100.0 | 0.0 | 33.3 | 88.9 |
| 2 | IOF-CORE | 58.0 | 66.7 | 0.0 | 57.5 | 84.9 |
| 3 | SIMPM | 40.4 | 33.3 | 0.0 | 47.1 | 100.0 |
| 4 | GRACE | 34.0 | 33.3 | 0.0 | 41.2 | 63.2 |

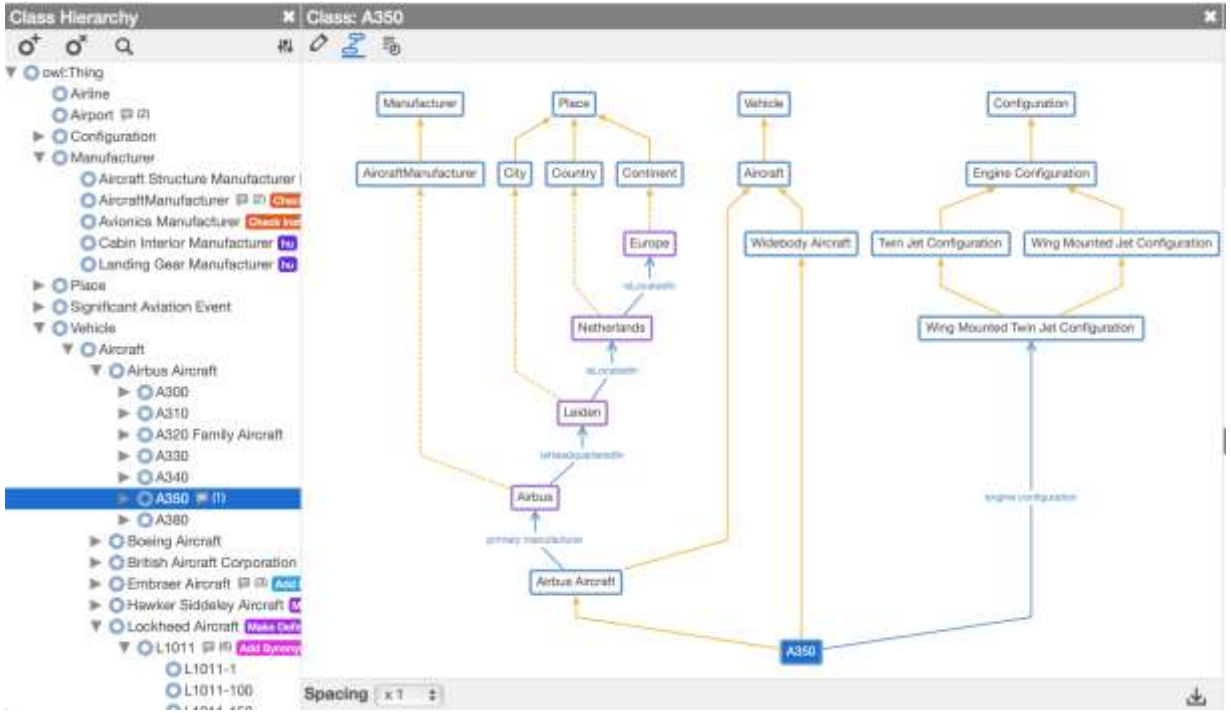


# Ontology Editing (and data documentation)

- Two primary editors (completely free, natively hosted) are recommended.
- Currently being integrated to the ecosystem platform (IndustryPortal)

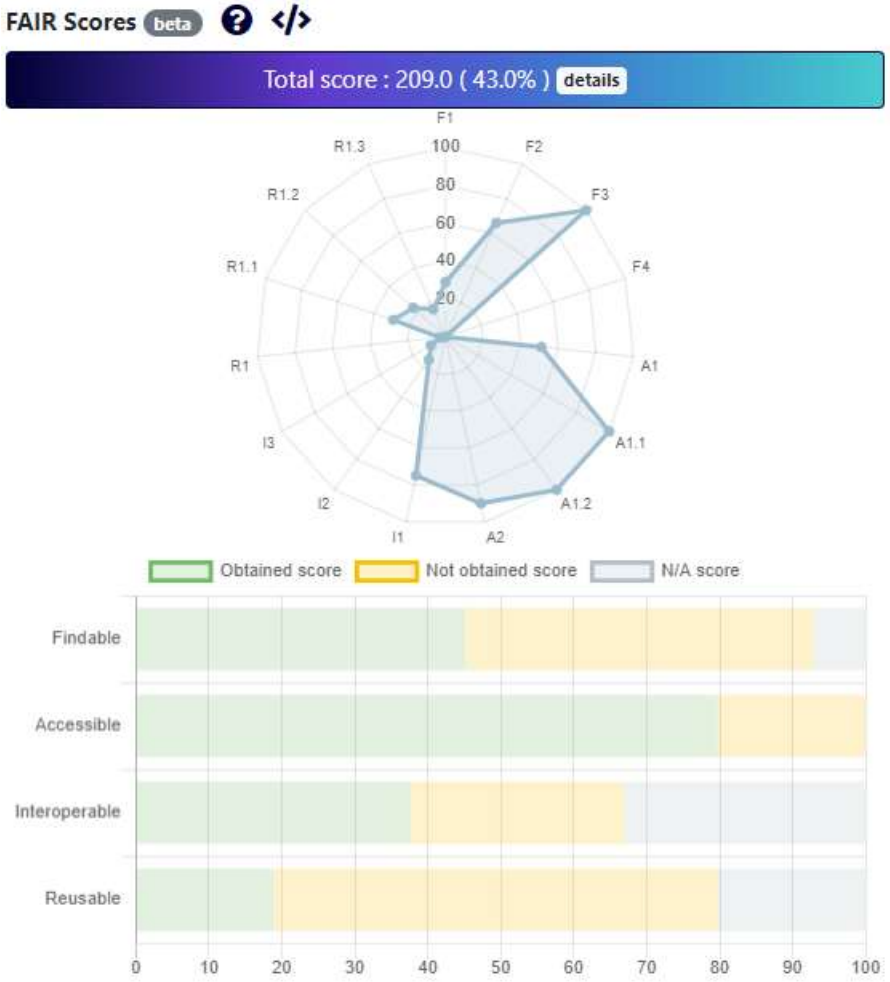


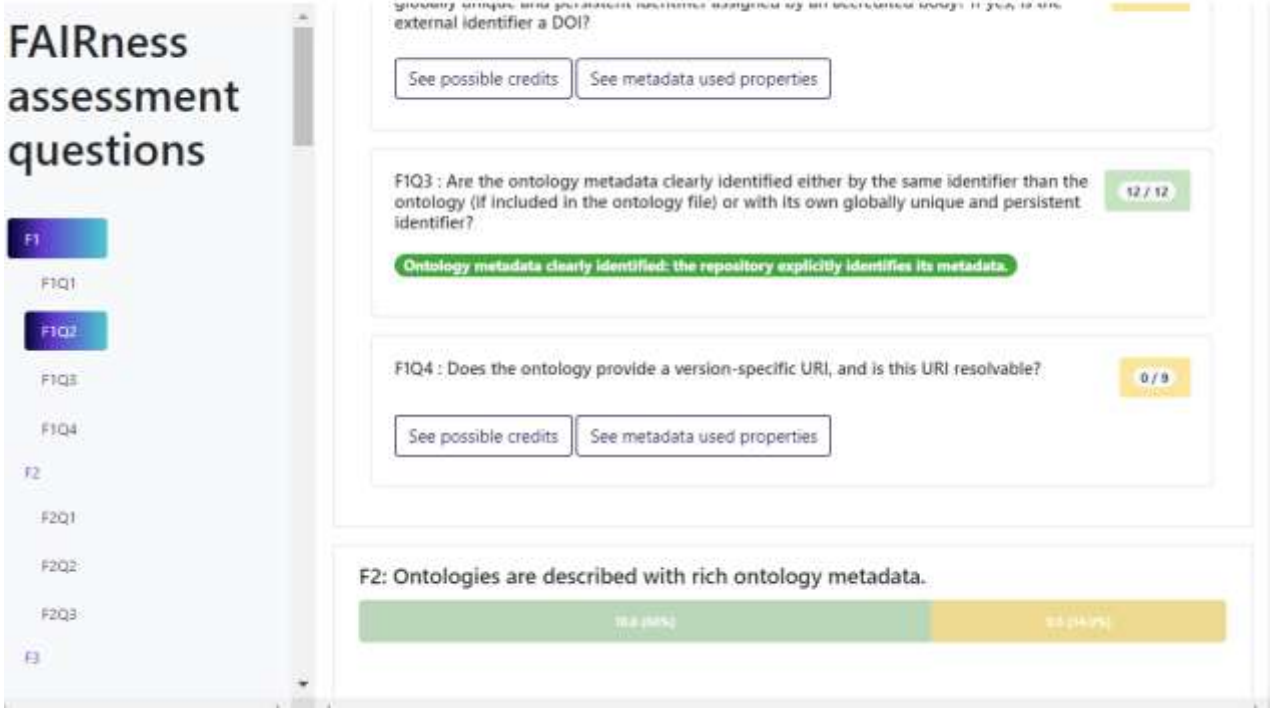
SousLeSens



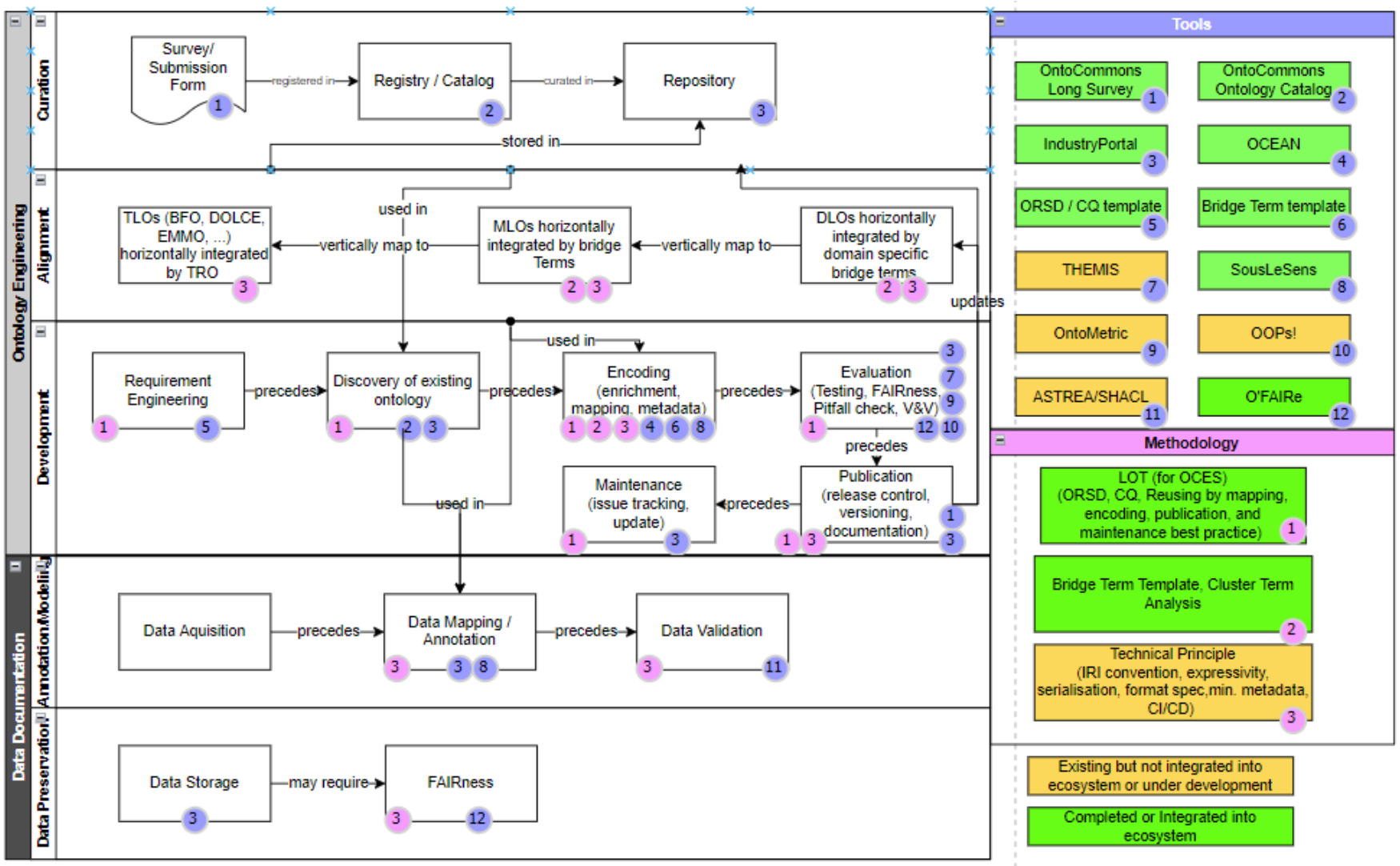

OCEAN (Web-Protégé)

# FAIRness improvement with O'FAIRe in IndustryPortal



# Summary


Ontology Engineering
Curation
Survey/ Submission Form
registered in
Registry / Catalog
curated in
Repository
stored in
Alignment
used in
TLOs (BFO, DOLCE, EMMO, ...) horizontally integrated by TRO
vertically map to
MLOs horizontally integrated by bridge Terms
vertically map to
DLOs horizontally integrated by domain specific bridge terms
updates
Development
used in
Requirement Engineering
precedes
Discovery of existing ontology
precedes
Encoding (enrichment, mapping, metadata)
precedes
Evaluation (Testing, FAIRness, Pitfall check, V&V)
precedes
Publication (release control, versioning, documentation)
precedes
Maintenance (issue tracking, update)
used in
Data Documentation
Annotation/Modeling
Data Aquisition
precedes
Data Mapping / Annotation
precedes
Data Validation
Data Preservation
Data Storage
may require
FAIRness
Tools
OntoCommons Long Survey
OntoCommons Ontology Catalog
IndustryPortal
OCEAN
ORSD / CQ template
Bridge Term template
THEMIS
SousLeSens
OntoMetric
OOPs!
ASTREA/SHACL
O'FAIRe
Methodology
LOT (for OCES) (ORSD, CQ, Reusing by mapping, encoding, publication, and maintenance best practice)
Bridge Term Template, Cluster Term Analysis
Technical Principle (IRI convention, expressivity, serialisation, format spec,min. metadata, CI/CD)
Existing but not integrated into ecosystem or under development
Completed or Integrated into ecosystem

ONTO COMMONS
ONTOLOGY-DRIVEN DATA DOCUMENTATION FOR INDUSTRY COMMONS

# Thanks

*Questions?*

**FOLLOW US ON**

**Contact**


www.ontocommons.eu

Arkopaul Sarkar, asarkar@enit.fr

Hedi Karray, mkarray@enit.fr (Technical Coordinator)



OntoComm ons “Ontology-driven data documentation for Industry Commons” has received funding from the European Union’s Horizon Programme call H2020 -NMBP-TO-IND-2020-singlestage, Grant Agreement number 958371