ONTO COMMONS

ONTOLOGY-DRIVEN DATA DOCUMENTATION FOR INDUSTRY COMMONS

OntoCommons

ROADMAP

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ONTOLOGY-DRIVEN DATA DOCUMENTATION FOR INDUSTRY COMMONS

OntoCommons Roadmap

https://ontocommons.eu/roadmap

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OntoCommons “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

OntoCommons Roadmap

considers a number of topics contributing to an Ontology Commons Ecosystem for ontology-based data documentation:

1. Ontology Foundations: Top Reference, Middle, Domain and Application Levels
2. Integrated Development Environment (Tools) and Infrastructures
3. Industrial Impact including Marketplaces, Standardisation, Education and Human Resources

The Roadmap presents:

Needs, State of the Art, Gaps, Definition of Success and Recommended Actions

Industrial Impact

The adoption of ontology-based data documentation and knowledge management practices in industry is still at a low level, with some noteworthy exceptions.

To reach wider adoption and impact, the ontologies, tools and infrastructure, as well as human resources, need to be developed.

Industry can expect to reap substantial benefits including:

- Standardised data documentation and FAIR data within and across organisations;
- Improved communication within a company;
- Time and cost saving;
- Increased innovation capacity; and
- Optimised product quality and environmental footprint.

Industrial Impact

- In addition to the benefits for individual companies, there are huge untapped opportunities of data sharing in an “Industry Commons”.

- A system of digital marketplaces can support needs such as data integration and interoperability, as well as improving the transfer of data between industries and marketplaces.

Roadmap Chapters

- **TOP Reference Ontology**
- **Industrial Domain Ontologies**
- **Ontology Commons EcoSystem Toolkit**
- **Infrastructure**
- **Industrial Application**
- **Standardisation**
- **Knowledge Management Translator for Industry Commons**
- **Ontology-based digital-marketplaces cooperation**
- **Innovation and perspectives**

Needs
State-of-the-art
Gaps
Definition of Success
Recommended Actions

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- Chapter 3.2 – Domain Ontologies

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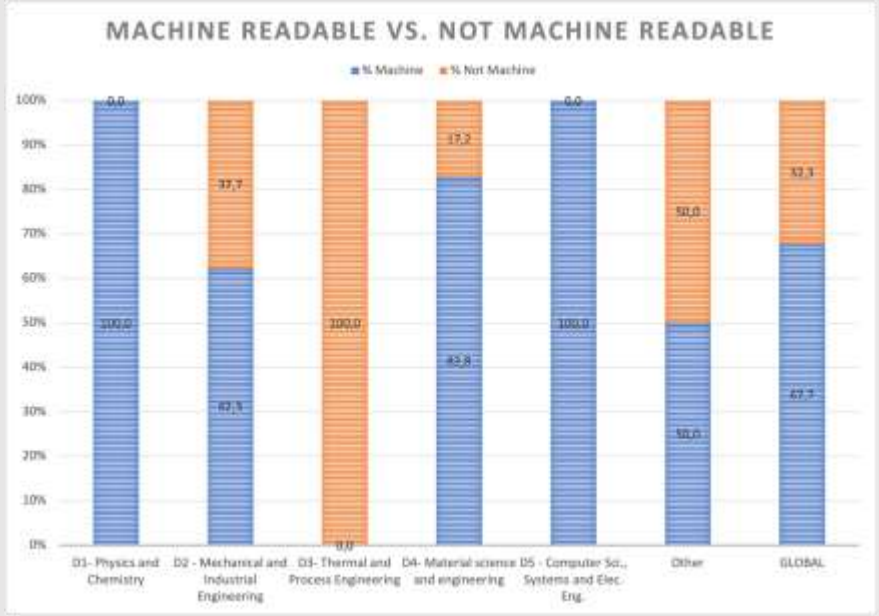
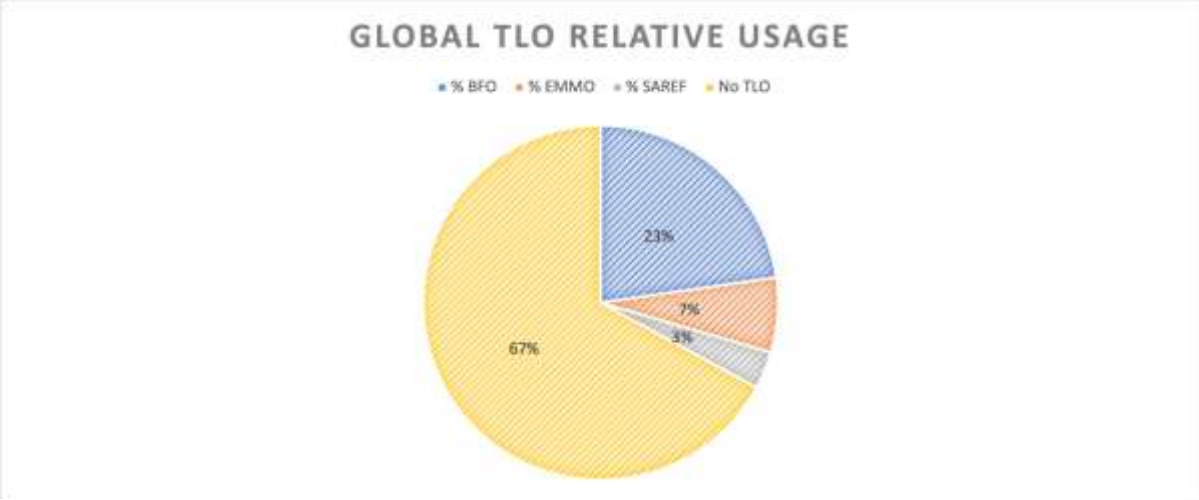
Industrial Needs

- **Data integration and sharing**
  - There is a unanimous understanding in the industrial stakeholders that they will be benefited from an improvement of data integration, sharing and format conversion, while 70% of the respondent of a survey conducted responded that they have started or already adopted such standards in their practice.
- **Standardisation**
  - Though there are many standards available for the domain of material and manufacturing, there is a general lack of consensus among these standards. while in some of our domains we have standards at the level of ISO (as per 2/3 of respondents being in favour), in others we are very far from that (e.g., a CWA). Though there is no doubt that standards are key, they are very hard/impossible to be produced within the timescale of a typical EU project, unless the project is really about just producing the standard.
- **Various domain Perspectives**
  - Regarding domain ontology development a major problem is how to combine various views and domains. According to industry, it is still an unsolved problem in engineering.
- **Interface domain ontologies with TLOs**
  - The interface to TLO is more relevant from the point of view of developers of domain ontologies but not the intricacies of the TLO. In other words, we should "isolate" the domain ontologies from the TLO's theoretical and technical details.
- **Link domain experts to Ontologists**
  - The domain experts and ontologists complement each other's role where the former brings the domain level requirements and help in characterising the ontology terms from domain's point of view and the latter provide formalisation in the ontology model using theoretical grounding and ontology engineering best practices.

State-of-the-art





222 collected entries out of which we identified initially a total number of 108 relevant ontologies including 74 machine-readable ontologies vs 34 non machine-readable ontologies.

Domain	Ontology Name	FAIR Score	Global FAIR Score	FOOPS! score
D1 Physics and Chemistry	Chemical Methods Ontology	50	46.2	39
	Reaction ontologies	50	46.2	48
	CHEBI	50	53.8	14
	Chemical Analysis Ontology	37.5	46.2	29
	Chemical information ontology	37.5	46.2	39
	NanoParticleOntology	25	46.2	38
	EMMO-Crystallography	25	38.5	44
	EMMO-Atomistic	25	38.5	31
	CIF Ontology	12.5	23.1	54
	Average (± STD)	34.7% (±13.7%)	42.7% (±8.7%)	37.3% (± 11.7%)

Gaps

- **Models Granularity**
  - Need for more extensive and granular models addressing areas of manufacturing and materials.
- **Lack of Generic and Application-specific Ontologies**
  - A general lack of ontologies that covers fundamental and application-specific physics and chemistry-related topics
- **Lack of standardised methodology and tools**
  - Although number of existing ontology development methodology and tools are available, no such methodology and tool have been standardised with a wide agreement from the community. Furthermore, no significant methodology and tool specific to harmonising ontologies is available.
- **Ontology as a conceptualization of reality vs information model**
  - The need of ontology is to formalize the terms used by engineers in the manufacturing field. Engineers often find it difficult to change their perspective because they find it difficult to connect their domain-specific view to a global point of view.
- Ontology Sustainability
  - Many good quality ontologies are lost due to lack of maintenance and not found wider adoption. A lack of sustainable strategy also hinders the development and maintenance of the ontology and ultimately the quality. Because of this lack of quality, some of the ontologies lose trust among industrial users.
- Lack of Standardised Method for Domain Ontology Evaluation
  - The quality and coverage of DLOs need to be evaluated by formal methods.

Recommended Actions

- **Standardization of the ontology engineering steps**
  - Standardize every facet of the domain ontology engineering steps. Some of the recommendations for standardizing the ontology engineering method is to adopt one of the formal methodologies such as LOT including the use of well-defined competency questions for requirement engineering and validation of the ontology using well-defined completion criteria.
- **TLO-MLO Alignment**
  - Adopt a coherent top-level ontology and a set of mid-level ontologies to ensure interoperability across domains in the domain ontology model.
- **Balance of Theory and Practice**
  - Adopt a Hybrid approach for the definitions of terms in the domain ontology by making a balance between utility and deep ontological (philosophical grounding) analysis on the conceptualisation and the formalisation.
- **FAIRNESS**
  - Make domain ontologies FAIR by storing the ontology in a permanent ontology repository specific to the industry (industryportal), adopting FAIR metadata for annotation and documentation. At the same time, the current proposals for FAIR metadata require enhancement to support domain ontology alignment and FAIRification at the content level (classes and relationships).
- Follow Domain related standards
  - While building an ontology for a certain domain area, existing standards covering that topic need to be identified and ontologized as much as possible. As the nomenclature of these standards is already well accepted in the community, they need to be directly adopted in the ontology.
- Classify domains
  - Standardized domain classification needs to be globally implemented to Classify all existing, under development, and future ontologies (domain level) as per their target domain.
- Bridging the gap between domain experts and ontologists
  - Supporting educational, training and professional development needs and in particular supporting a ‘Translator’ role, able to bridge gaps in the stakeholder value chain from ontology design to exploitation for data documentation

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- Chapter 5.1 - Industrial Application

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Industrial Needs

Need #	Need Description
People	
1	**Ease of interoperability and communication between different stakeholders** The ontology development tools should allow different stakeholders to work simultaneously and the ontologies should provide a "commons language" for this to happen.
2	**Best practices for data model governance as well as modelling tools** Industrial stakeholders need best practices about how to maintain data models and intuitive tool support. This is particularly important for bringing domain experts on board.
Data	
3	**Easy to use and to understand ontologies** The industry needs ontologies that are easy to use and understand. They need to be applicable without much explanation. This points out to the need for proper documentation and concrete examples of usage for ontologies.
4	**Improved reusability of (meta-)data and processes** With little or no use of standard vocabularies and ontologies the reusability of (meta-)data is not very high.
Processes	
5	**Time savings in industrial processes** One of the main industrial needs is to saving resources, particularly time in industrial processes. Time savings is expected in terms of increased automation for tasks like decision making and interaction between different actors.
6	**Avoidance of physical testing** In many industrial processes, it is desired to avoid physical testing and create reliable simulations for resource and cost saving reasons. The need for simulation particularly manifests in manufacturing, for example in aircrafts.

Gaps

GAP #	GAPS
People	
1	**Learning barriers for semantic technology in the industry** The ontology development and its support tools should be made more intuitive for easy introduction of semantic technology in industry. **This is particularly important for bringing non-ontology experts on board.**
2	**High cost of ontology development** Related to the end, ontology development incurs high costs due to high learning barriers for non-ontologists. This gap hinders the fufillment of reusability of data, metadata and processes
3	**Ontologies are difficult to maintain** The ontology shall be easy to maintain (e.g. adding lower level terms, additional relations, etc.) from non-ontology experts (e.g. SW engineers).
4	**Company internal/partner interaction should be optimised** Currently it is a major gap across many industrial parties to speak a common language during development of industrial processes. Tooling and methodologies are not mature for enabling such communication (e.g. between domain experts and ontology developers)
Data	
5	**The ontologies are not well documented** The ontology documentation should define how the reuse and harmonisation of different ontologies could be achieved. This also includes the formal documentation of ontology where formal constraints and scope are clear.
6	**Lack of comprehensive domain ontologies in NMBP domains** There are many domain ontologies scattered around however there are not many reference domain ontologies that cover a large portion of their domain and contain canonicalized definitions of concepts and their relationships

Gaps

	Data
7	**Arguments for using FAIR principles** It is not always clear for industrial stakeholders what that concrete benefits of application of FAIR principles are. This contributes to the natural barriers occuring in front of further FAIR adoption.
8	**Dealing with content protected with IPR** Many industrial standards are protected with licenses that prevent publishing derivations of the work. This hinders the creation of semantic resources from those standards. From a data perspective, this also creates a hinderence for FAIR adoption.
9	**The ontologies should follow higher level ontologies** The aligned ontologies should follow top or mid-level ontologies to allow a higher compatibility with other ontologies
10	**Interoperability between TLOs** There should be interoperability between TLOs to facilitate harmonisation of ontologies allowing for interoperability among ontologies that are based on different top-level ontologies.
Processes	
11	**Lack of standards and guidelines** Although ontology usage is there to some extent, there are still challenges in terms of heteregoneity of ontologies and lack of standards for alignment as well as documentation. There is also a lack of comprehensible methodology.

Gaps

Tools	
12	**User interface** There are already tools like Protege used for ontology development, however the user interfaces can be incomprehensible, particularly for non-ontology experts.
13	**Tools for ontology engineering are not complete** The tools shall support visualisation, debugging, validation, search of existing ontologies and import. Tools shall be provided to support initial brainstorming and conceptualisation on models of concepts relevant for the domain and applications, to enhance transition from initial ideas to standard tools
14	**Maturity of the (collaborative) ontology development tools** The ontology development tools are not always intuitive and easy to use. One needs to have already some experience with ontologies, their structure and what are the possibilities in order to be able to use the existing development tools. Many of them also have serious drawbacks in terms of collaborative development.
15	**Lack of easy to use tools to put ontologies in production** Not only developing an ontology, but also deploy them in the production envrionments need intuitive tool support. Such tools may include reasoners to support an application with inferred knowledge as well as declaritive mapping languages and tools for populating an ontology with instances and NLP tools that use ontologies as a basis for knowledge extraction.

Definition of Success

#	Definition of Success
People	
1	**Improved communication within company personnel and with external partners** Using a “common language”, i.e. ontology and vocabularies, the communication between stakeholders will improve. This can be also seen as a consequence of achieving standardized data documentation from people perspective.
Data	
2	**Achieving standardized data documentation** Achieving standardized data documentation, typically via ontologies is seen as a sign of success for many industrial stakeholders. Such data documentation increases Findability, Interoperability and Reusability of data within and across organizations for different projects and allow companies to increase their innovation capacity.
Processes	
3	**Time and cost saving** An important factor for all industrial customers is time saving saving costs can also be important for customers, but saving time is more globally comprehensible. (e.g. ontology-enabled automation, optimized communication, more efficient integration across systems, and improved reusability)
4	**Optimised product quality and environmental footprint** Many industrial stakeholders provided a KPI for improving product quality and reducing environmental footprint e.g., in terms of CO2 emission
5	**Gaining competitive advantage for small and large companies** Small and large companies can benefit from the use of ontologies. Large companies can benefit because they repeat a process very often. Small companies can benefit from the time improvement because they are faster than the competition.

Recommended Actions

Action #	Recommended Action
People	
1	**Knowledge engineering education** A major gap on ontology development and usage is the high cost and struggles of finding trained people. Trainings on ontology usage and development issues is an important point, to allow early education on ontologies. This education must be adaptive to the needs and competencies of various stakeholders.
2	**Demonstrate examples on saving time and cost** Examples and success stories should be shown on the topic of time and savings to increase awareness of the benefits.
3	**Networking** Networking events where people share their experience with ontology adoption in industrial settings may be beneficial for a large audience and increase engagement.
4	**Highlight advantages of ontology usage** Demonstrate what the use of ontologies can do. This can be done by establishing a translator role in companies (see Section 5) and disseminating success scenarios with conrete improvements on specifc KPIs (e.g., increased automation, time saved, reduced carbon footprint)
Data	
5	**Data sharing and standardisation** Several gaps are related to reusability of (meta-)data and lack of standardisation. Ontologies make data sharing and data standardisation easier/possible. In general, standardisation is crucial (e.g. for legal requirements). At the minimum, ontologies must be aligned with industrial standards as much as possible.

Recommended Actions

Data	
6	**Demonstration of FAIR benefits** **I**ndustrial stakeholders may need concrete examples of how adopting a specific or a set of principles will help them. The community should provide minimal examples to demonstrate the benefits.
7	**FAIR principles also for metadata** Implementation of all FAIR principles is hard, therefore implement it for metadata is a good starting point.
8	**Close cooperation with FAIR communities** Close cooperation with communities, use/development of standardized tools for the implementation and the evaluation off FAIR principles. This will also help to clarify the misunderstandings about FAIR principles that prevent further adoption.
Processes	
9	**Follow good ontology development practices and provide a comprehensible methodology** This would guarantee high quality of ontology development. The best practices must be supported by comprehensive methodologies to enable sustainable development of ontologies.
Tools	
10	**Increase user-friendliness of tools** The most major gap regarding tools is their usability. Tools should be user friendly, complex details should be in the background. Tools must be developed more user centric with a constant feedback regarding the usability. Research and Development projects targeting higher TRL can include usability testing of developed prototypes as a criterion.
11	**Support development of collaborative, modular and open tools for ontology development** One thing we heard from almost all stakeholders is how challenging it is for them to find a tool for ontology development. The development of a collaborative, extensible and open ontology development tool must be supported. The tool should provide open APIs for developers to develop plugins or convert their existing tools into plugins.

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- Chapter 5.4 - Ontology-based digital-marketplaces cooperation

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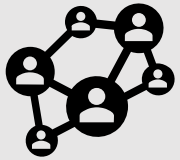
Digital-marketplaces are **multisided collaborative** and **trading platforms** that facilitate materials and manufacturing **innovation** by **easing access** to otherwise disparate sources and deployments of information, expertise, software applications and data.

Digital-marketplaces can benefit from the use of data models such as Taxonomies, Ontologies to:

- enhance the **meaningful exchange** of products and services
- achieve a **standardised representation** of information about **datasets** (*e.g.*: authors, owners licenses…)
- encode the "**IT system**" in an extensible, machine readable form (*e.g.*: IDS Information Model, GAIA-X Core Ontology …)

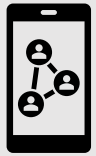
Industrial Needs

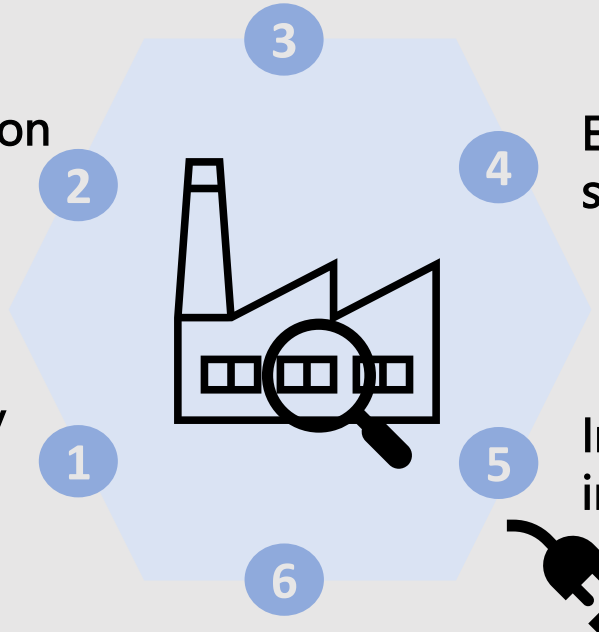
Better user-friendly platform



Interoperability based on common standards

Effective data exchange between simulators and databases





Integrating data generated by simulation and experiments

Improving transferring data between industries and marketplaces

Access possibility

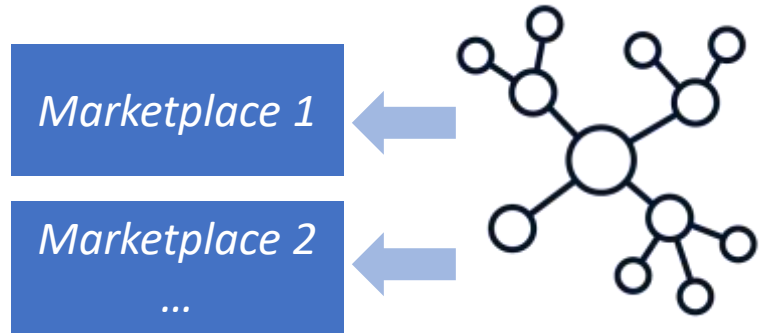
State-of-the-art

* The **digital marketplaces** are using ontologies for their **services and operations**

Current Scenario:

Project	Domain Knowledge	Dataset representation	Infrastructure
Market 4.0	N	N	Y
Weldgalaxy	Y	N	N
ViMMP	Y	N	Y
MarketPlace	Y	N	N
DOME 4.0	Y	Y	Y

Type of information captured by the used ontologies

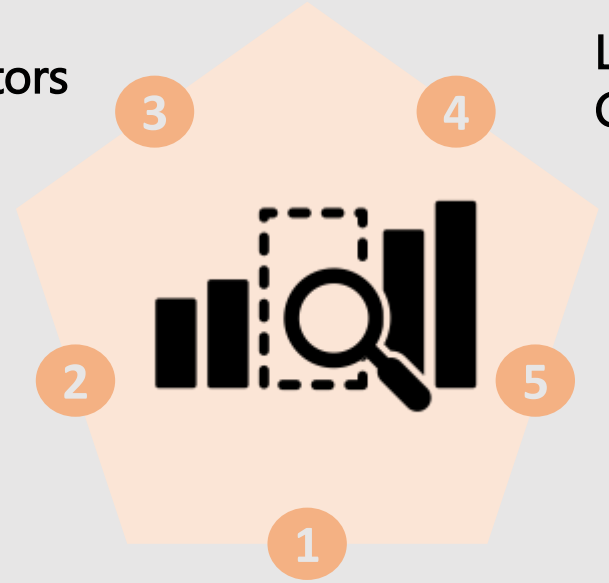


The ontology **EVMPO** (European Virtual Marketplace Ontology) was developed jointly by the projects involved in establishing the **EVMF** (i.e., VIMMP and Marketplace, with support from the EMMC-CSA project).

Gaps

Lack of demonstrators

Lack of user-friendly Graphical User Interfaces



Lack of tools and methodology

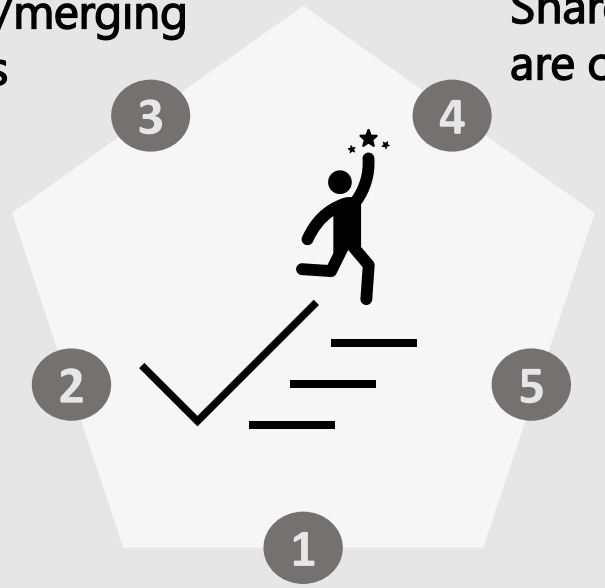
Better communication between EMMO and the marketplaces

Lack of communication between marketplaces to develop a common ontology

Definition of Success

Reuse of ontologies, integration/merging among marketplace applications

Share documents and technologies which are open among the marketplaces



Create a common space for sharing updates of each marketplace project

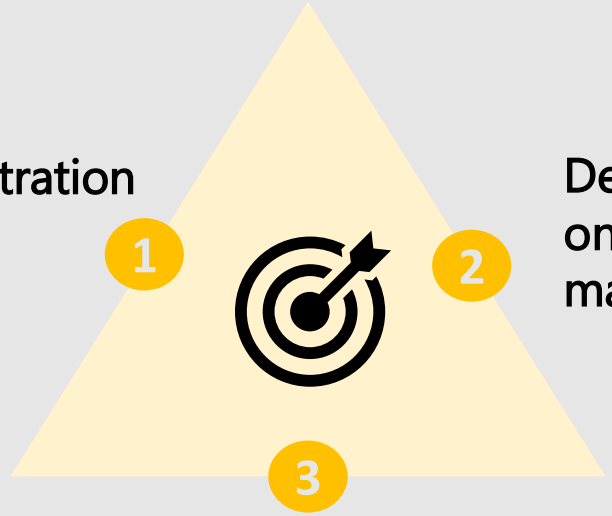
Share fundamental concepts and small (mid-level) ontologies that provide connection between marketplaces

Determined synergies (and 'common points') between the marketplaces

How can it lead to further collaborative developments?

Recommended Actions

1. Well-defined demonstration for marketplaces
2. Developing a common “global” ontology framework for the marketplaces
3. Establishing link between marketplaces



Common thoughts

Industrial Needs

- Data integration and sharing.
- Standardisation
- Various domain Perspectives
- Link domain experts to Ontologists
- Training on ontology engineering

Gaps

- Lack of Generic and Application-specific Ontologies
- Lack of standardised methodology
- Lack of user friendly tools
- Ontology Sustainability
- Lack of Standardised Method for Ontology Evaluation
- Lack of ontology experts
- Lack of understanding of FAIR

Recommended Actions

- Standardization of the ontology engineering steps
- **Balance of Theory and Practice**
- **FAIRness**
- **Follow Domain related standards**
- **Classify domains (an ontology of domains)**
- **Bridging the gap between domain experts, IT and ontologists**

Don’t forget to complete our survey of the OntoCommons Roadmap!
We’d like **your feedback** on:

- Industrial needs addressed
- Gaps highlighted
- Recommended actions
- Suitable timeline for the actions identified
- Anything that’s missing

Be active, be contributor

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