Bridge concepts for domain ontology alignment and data documentation

OntoCommons Ecosystem (OCES)

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OntoCommons Member and WP3 Lead

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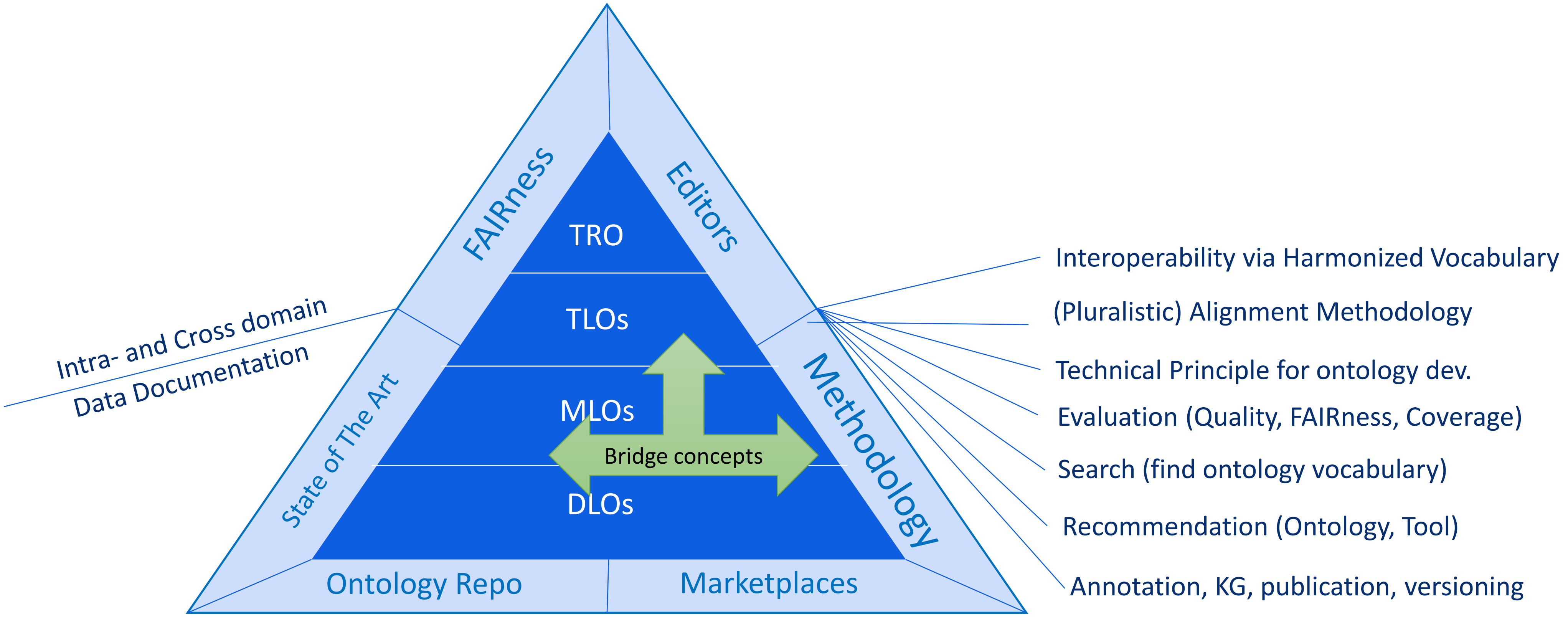
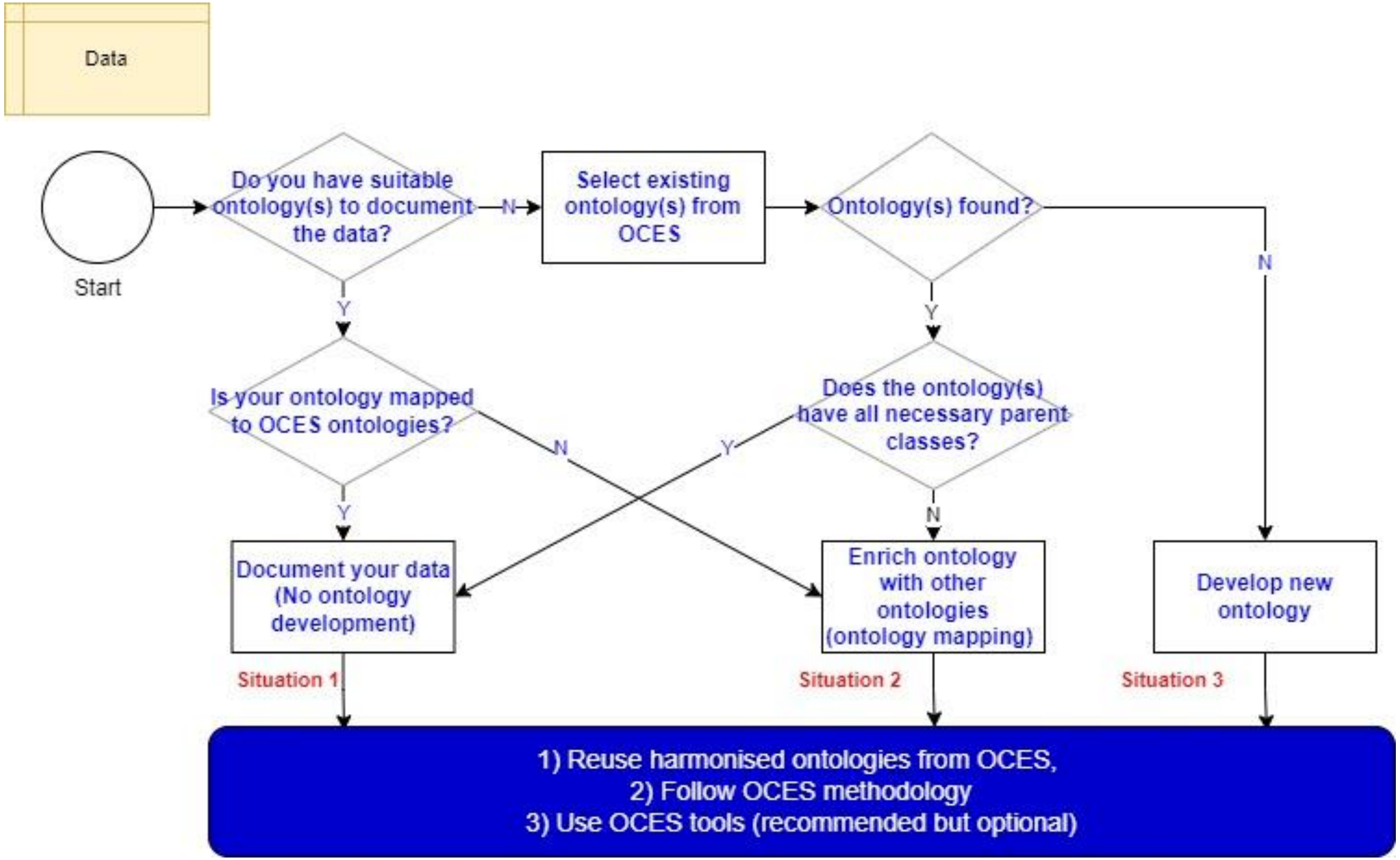
The most tangible outcome – OntoCommons Ecosystem

- 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.**

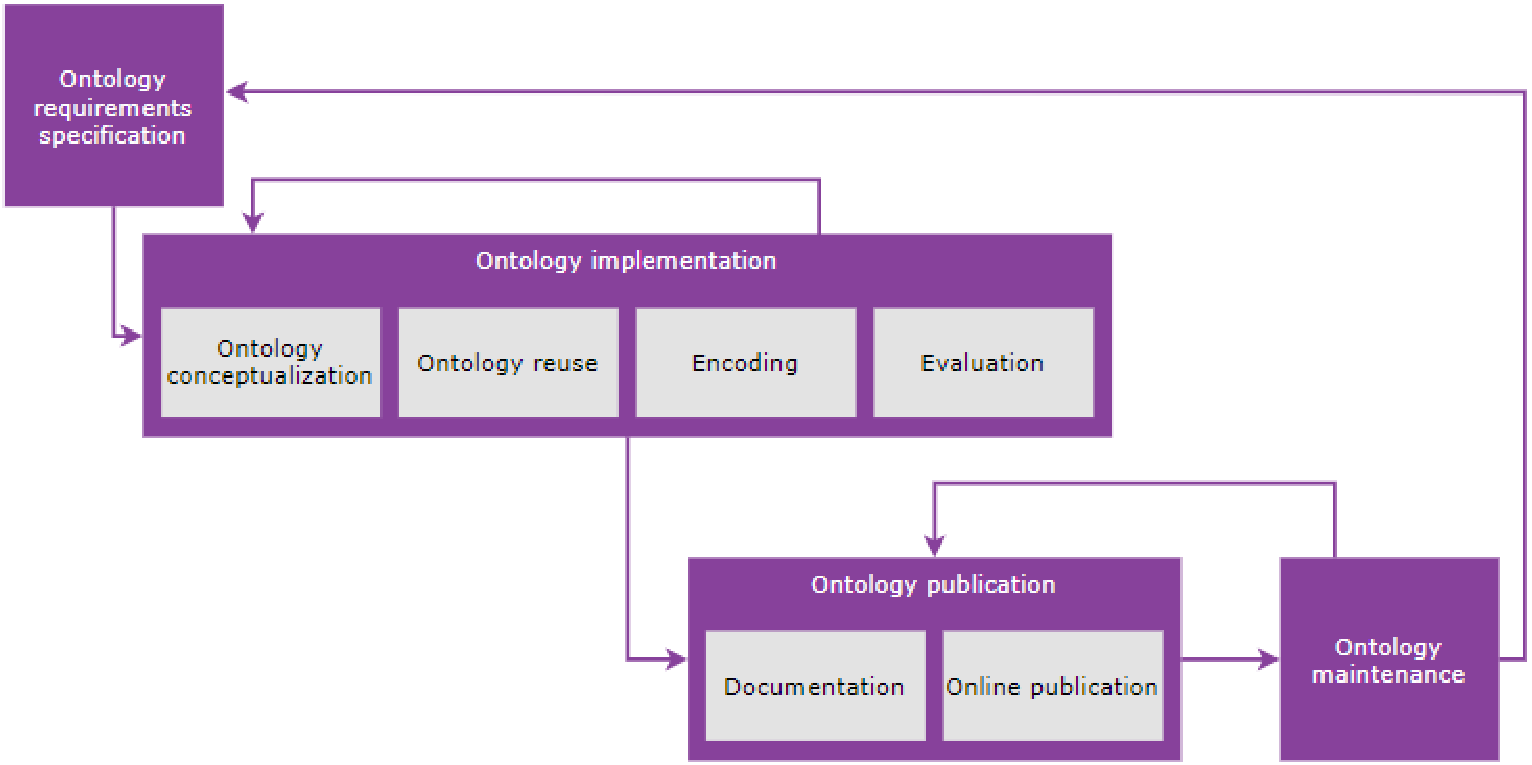


Different needs for data documentation

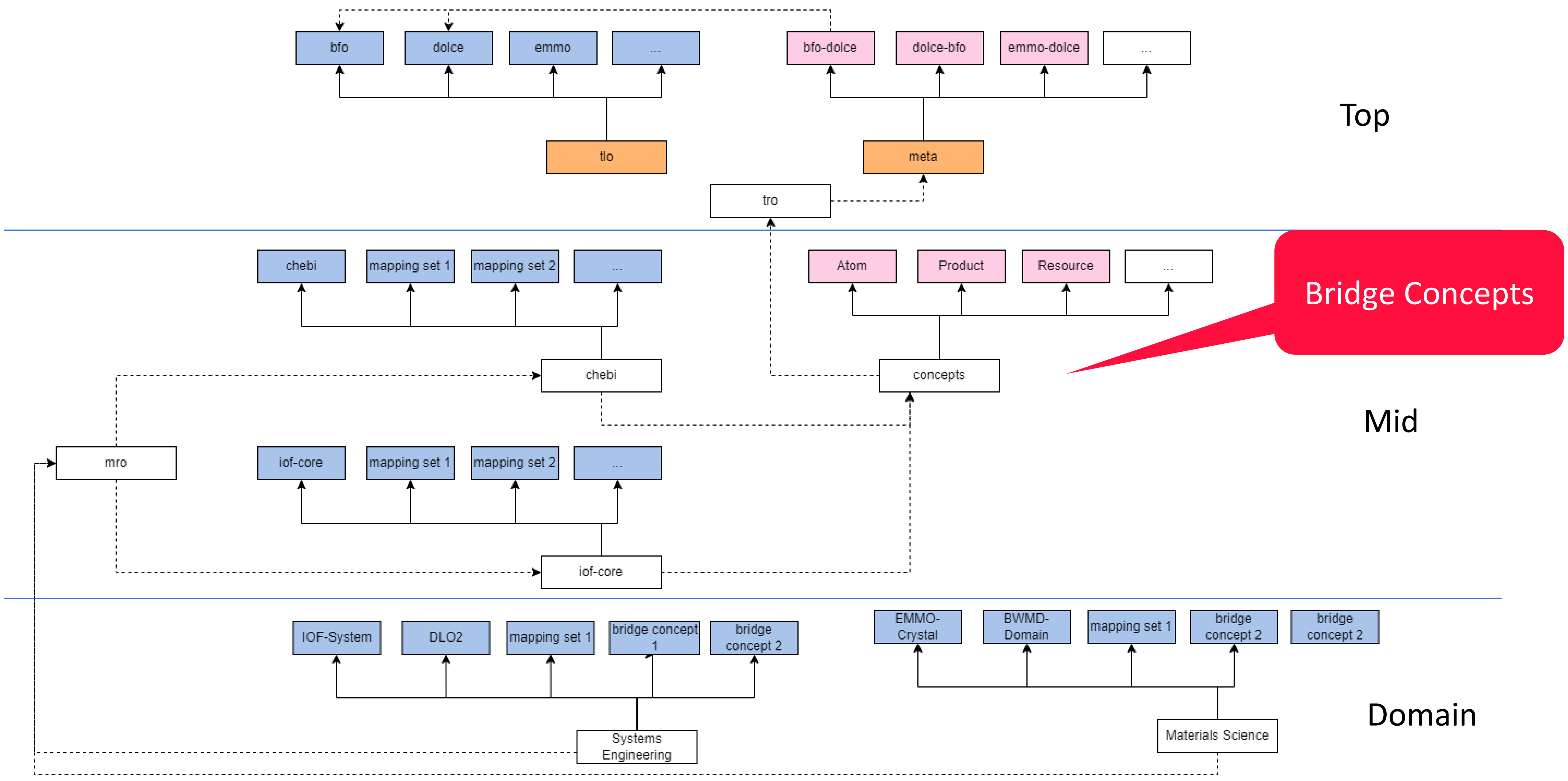


Develop new ontology

- Follow LOT methodology and Ontology Technical Principle

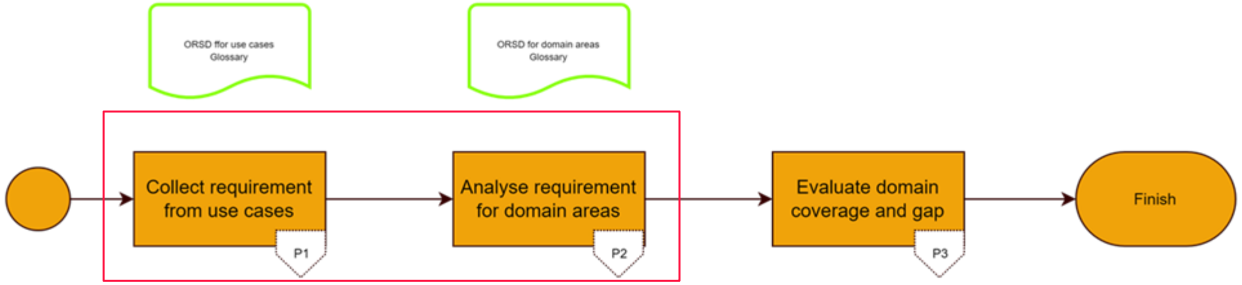


Reusing Ontology (Import ontology stack)



ONTO COMMONS
ONTOLOGY-DRIVEN DATA DOCUMENTATION FOR INDUSTRY COMMONS

Ontology Requirement Specification



CQ

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?	Buttsrap, 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

Terms list

1	Term	Wordnet synonym	UC	CQ	Hyponym (type of)	Meronym (part of)
16	**System**		1	16,17,18,22,24,30,32		
27						
28	Process	same.	2	1,2,4		
104	InanimatePhysicalObject		3	34		
105						
106	**Device**	none	6	1,16	logistic terminals, sensors, control system, and traffic routing	
107	**Service**	none.	6	2,12,13,14,19	site configuration for yard management and logistics on wareh	
108	Process	same.	6	3,12,13,14,16,19	truck indentification, weighting process	
109	**Action**	activity.	6	4,16,18	open a terminal barrier, display a message in a terminal, inforr	
110	**Vehicle**	none.	6	5,15,21		
111	Material	same.	6	6,7,12,15,21		
112	**Agent**	none.	6	7,9,10	vehicle driver, access manager, vehicle	
113	**Transportation**	transit, transfer, fare	6	7,12		
114	**Yard**	ground	6	8,20		

ORSD

	Ontology Requirements Specification Document
1	**Purpose (mandatory)**
	The use case aims to demonstrate: - decreased development time via automatized decision making and improved re-usability, - improved reliability via traceability, - 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 2) System engineering expert 3) Assembly process engineer 4) Simulation engineer
5	**Intended Uses**
	The system is expected to support decision-making during aircraft industrial system design. Some expected benefits include: 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. 2) Develop a cognitive twin based on captured domain knowledge, models and simulations. 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**

Domain coverage analysis

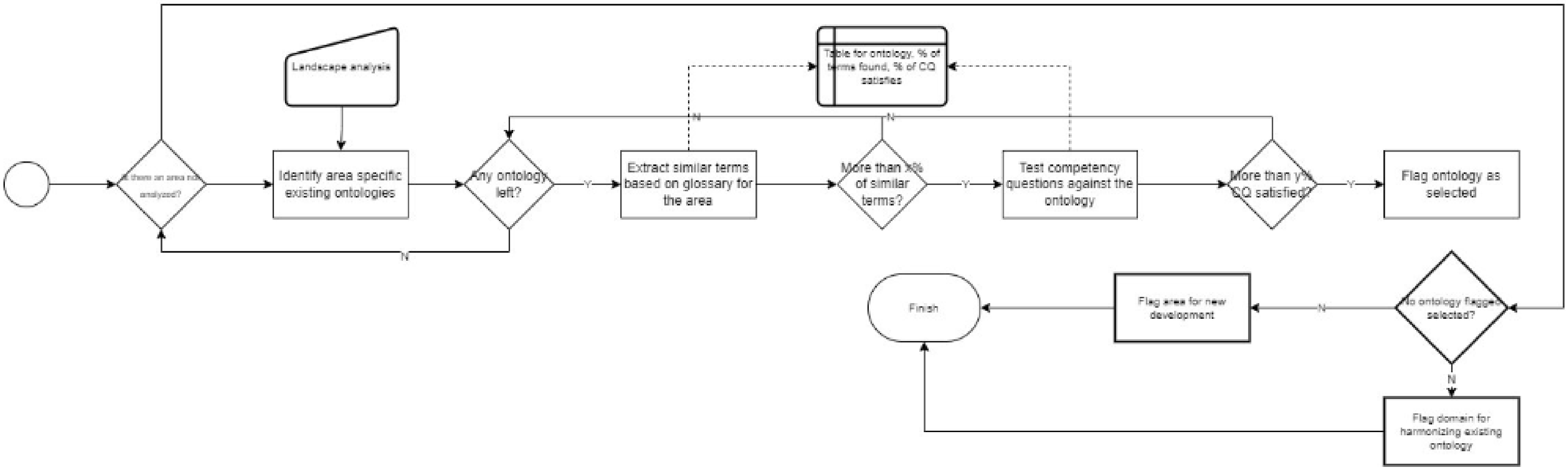


Figure 1 - General workflow of domain coverage analysis

Domain ontology harmonization

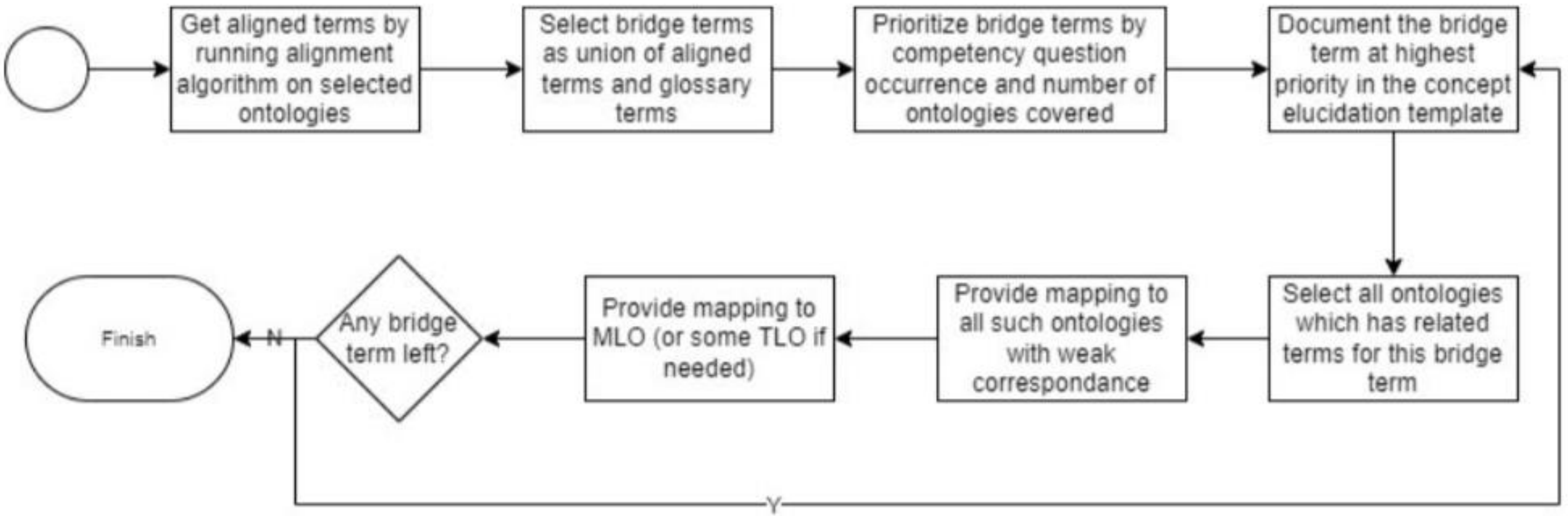


Figure 2 - General workflow of harmonization of domain ontologies

Hands on demonstration

- Assumes basic knowledge of ontology and reasoning.
- Familiarity with Protégé framework.
- The use case used is requires only application-level ontology with some domain reference or mid-level concepts.
- For top-level reference only BFO is used. Considers only IOF-Core and SAREF as reference ontology (they are at mid-level as per OCES stack).
- Multiple top-level scenario is not covered.
- Many other formalities (e.g., annotation, metadata, encoding format) are not covered.

Use case

Use case: Two temperature and one turbidity sensor monitors the water quality of a fish tank. Any turbidity reading more than 200 is considered unsafe.

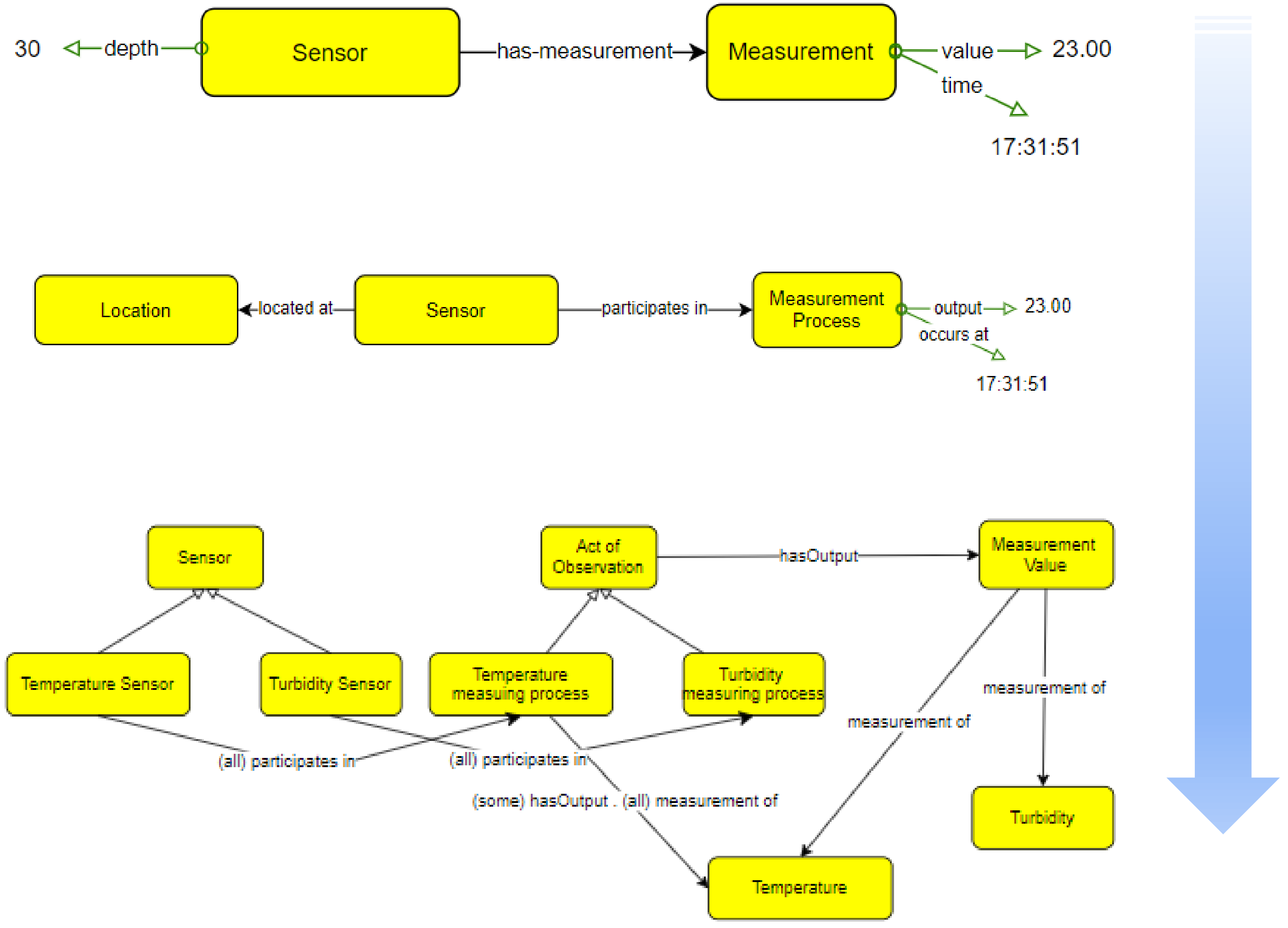
1	Sensor	TimeStamp	Temperature (C)	Turbidity (NTU)
2	temp-sensor-1 at 30 cm depth	09:22:08	20.03	
3	temp-sensor-1 at 30 cm depth	09:25:38	21.00	
4	temp-sensor-1 at 30 cm depth	09:29:08	20.92	
5	temp-sensor-1 at 30 cm depth	09:32:38	20.40	
6	temp-sensor-1 at 30 cm depth	09:36:08	20.31	
7	temp-sensor-1 at 30 cm depth	09:39:38	21.97	
8	turb-sensor-2 at 30 cm depth	17:31:51		191.52
9	turb-sensor-2 at 30 cm depth	17:35:21		192.24
10	turb-sensor-2 at 30 cm depth	17:38:51		191.45
11	turb-sensor-2 at 30 cm depth	17:42:21		191.19
12	turb-sensor-2 at 30 cm depth	17:45:51		210.13
13	turb-sensor-2 at 30 cm depth	17:49:21		192.78
14	turb-sensor-3 at 60 cm depth	17:31:51		192.43
15	turb-sensor-3 at 60 cm depth	17:35:21		190.46
16	turb-sensor-3 at 60 cm depth	17:38:51		191.86
17	turb-sensor-3 at 60 cm depth	17:42:21		194.70
18	turb-sensor-3 at 60 cm depth	17:45:51		192.68
19	turb-sensor-3 at 60 cm depth	17:49:21		192.56

ID	Competency Questions	Answers
1	What are the properties of water being measured?	Temperature, Turbidity
2	How temparature of the water is measured?	By temp-sensor-1
3	Where are the sensors located?	at 30 m and 60 m depth
4	When did the water become unsafe?	at 17:45:51

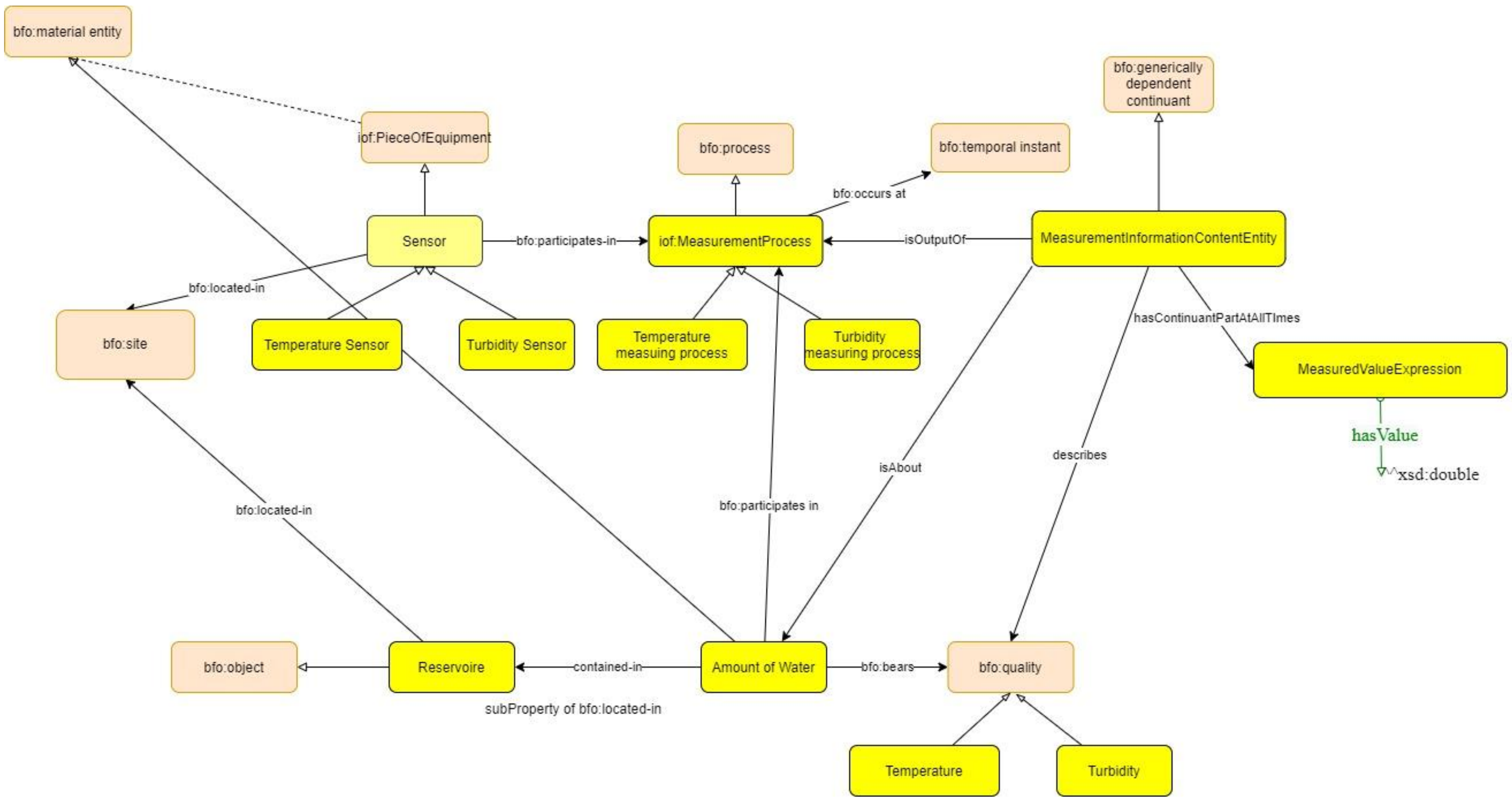
Terms
Sensors, Temperature Sensor, Depth, Turbidity, Measurement, Time….

Ontology Conceptualization

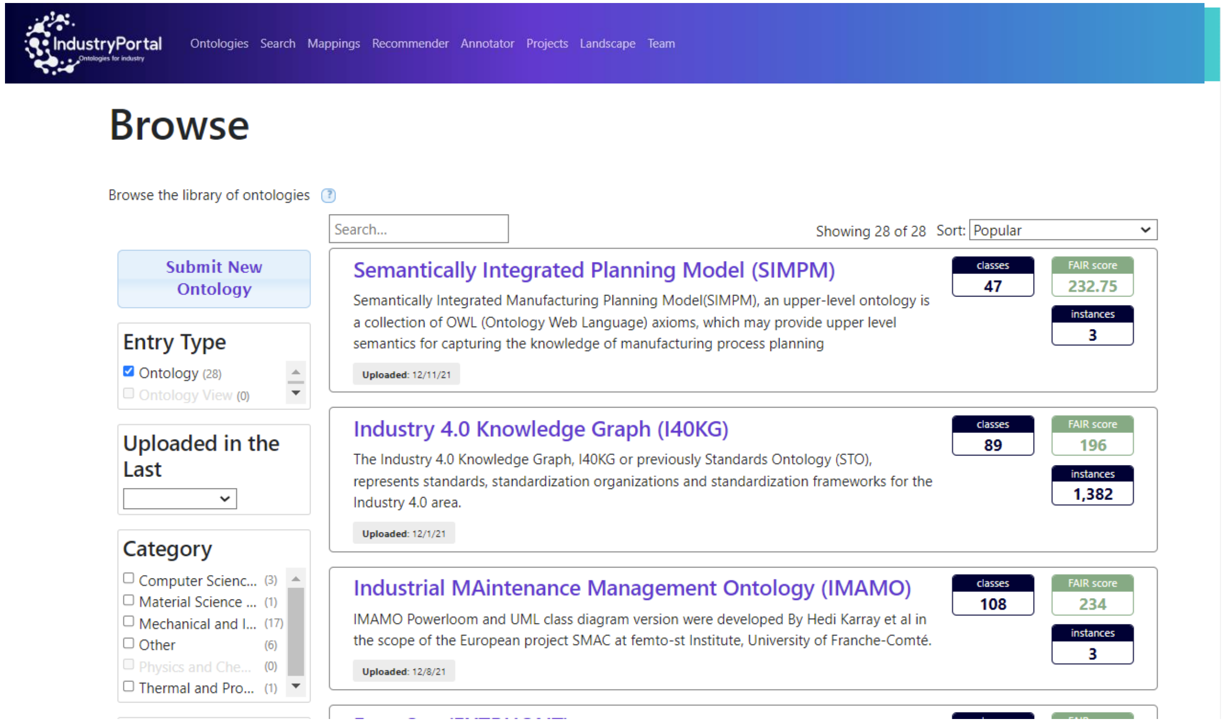
- Iterate to improve.
- Ontological thinking!
    - “What is” regression
    - Common sense
    - Foundational patterns from Top level.
- Replace specific relations with generic.
- Apply constraints to relations to derive definition
- Fix ontological commitment!
- Tool: Chowk (https://chowlk.linkeddata.es/)

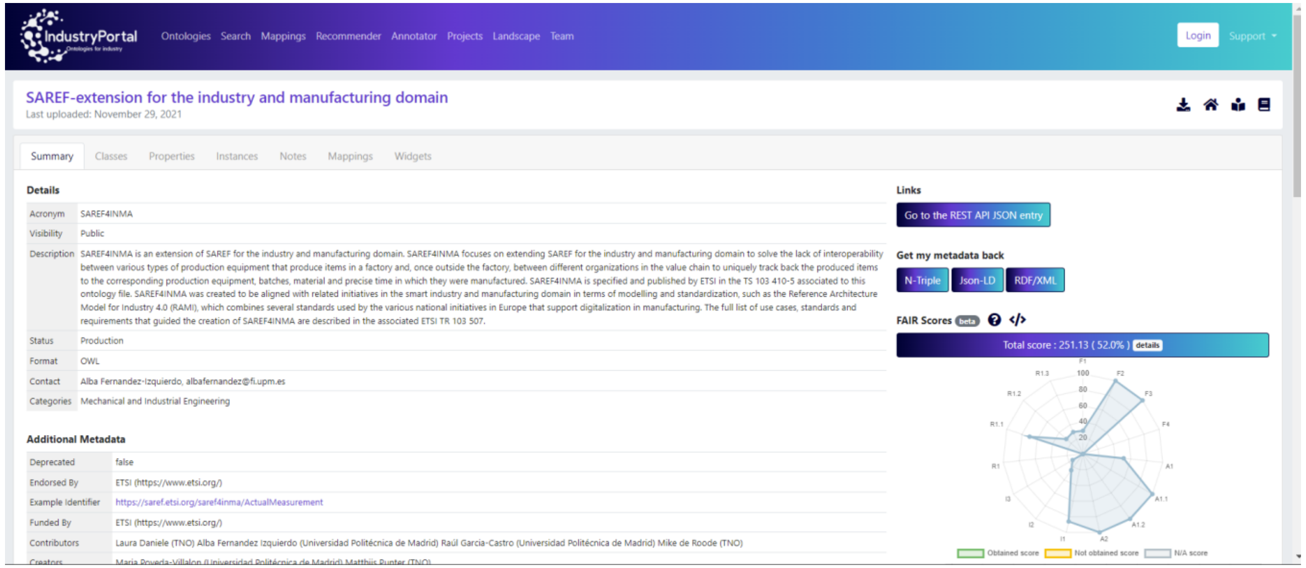


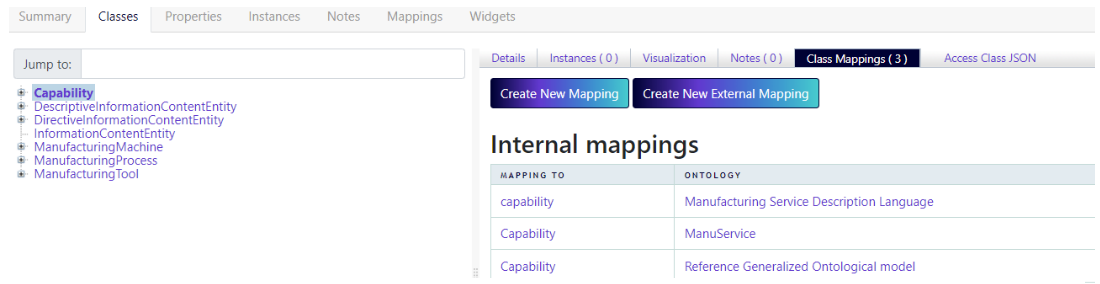
Ontology Conceptualization (cont.)

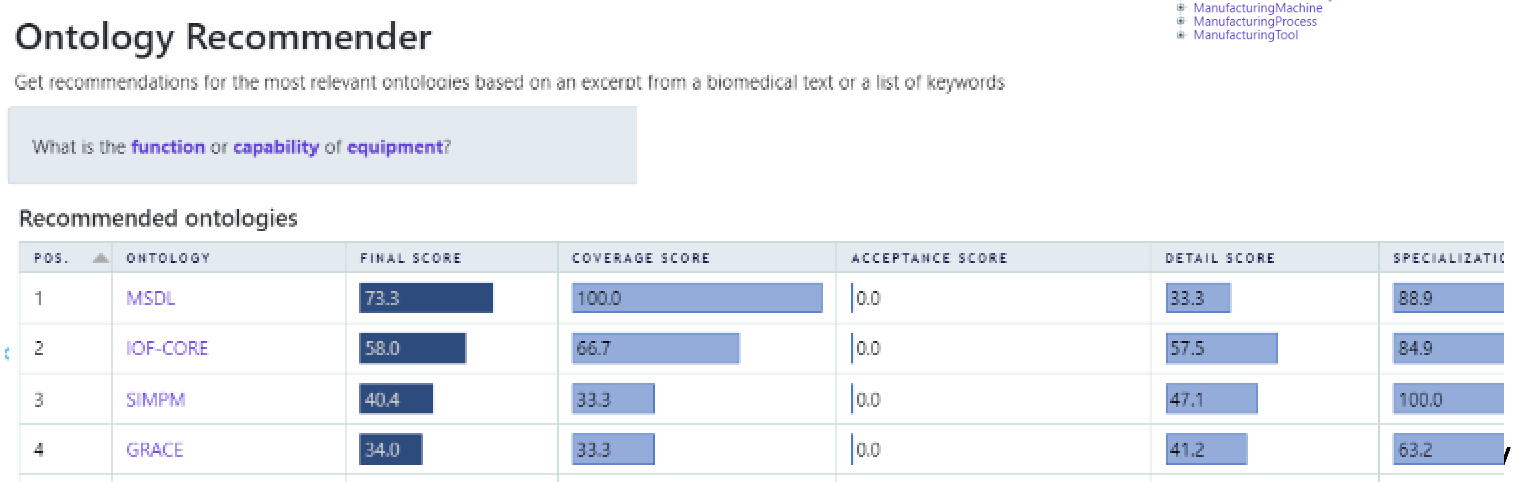


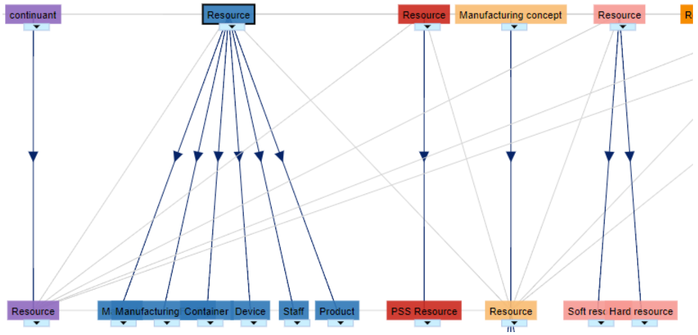
Reusing Ontology (IndustryPortal http://industryportal.space/)







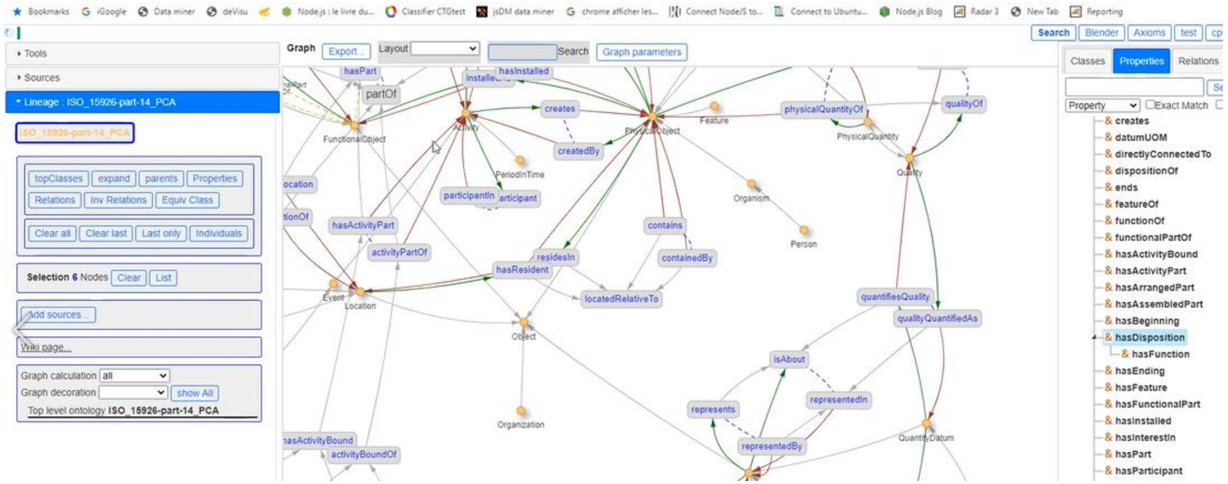




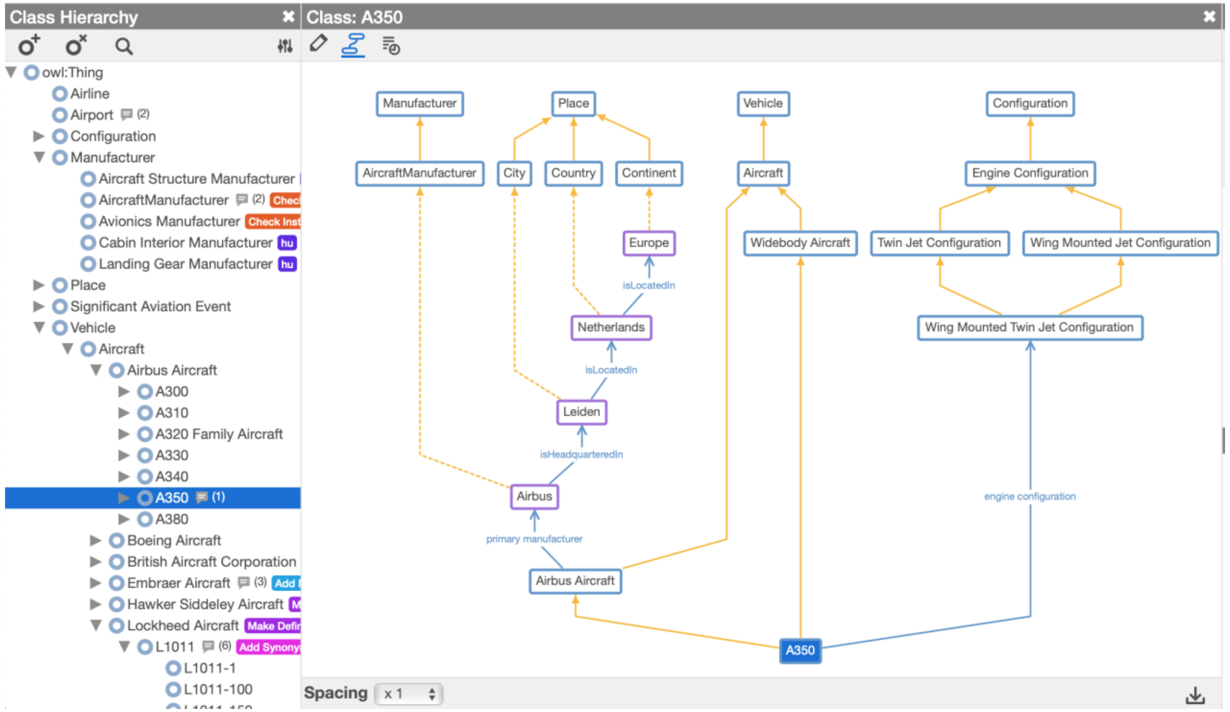
Download Ontology with Mappings (Under Development)

Ontology Encoding

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



SousLeSens



OCEAN (Web-Protégé) collaborative development

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

Ontology Encoding (OCES Technical Principle) cont…

- Language and expressivity
- Reasoner and prover
- Serialisation format
- Versioning scheme
- Development management and issue tracking

Annotating terms

Summary | Classes | Properties | Instances | Notes | Mappings | Widgets

Jump to:

- entity
  - continuant
    - generically dependent continuant
    - independent continuant
      - immaterial entity
      - material entity
    - specifically dependent continuant
  - occurrent
    - event
    - process
      - history
      - planned process
        - business process
        - computing process
        - **manufacturing process**
        - material location change process
        - measurement process
      - state
    - process boundary
    - process characteristic
    - spatiotemporal region
    - temporal region

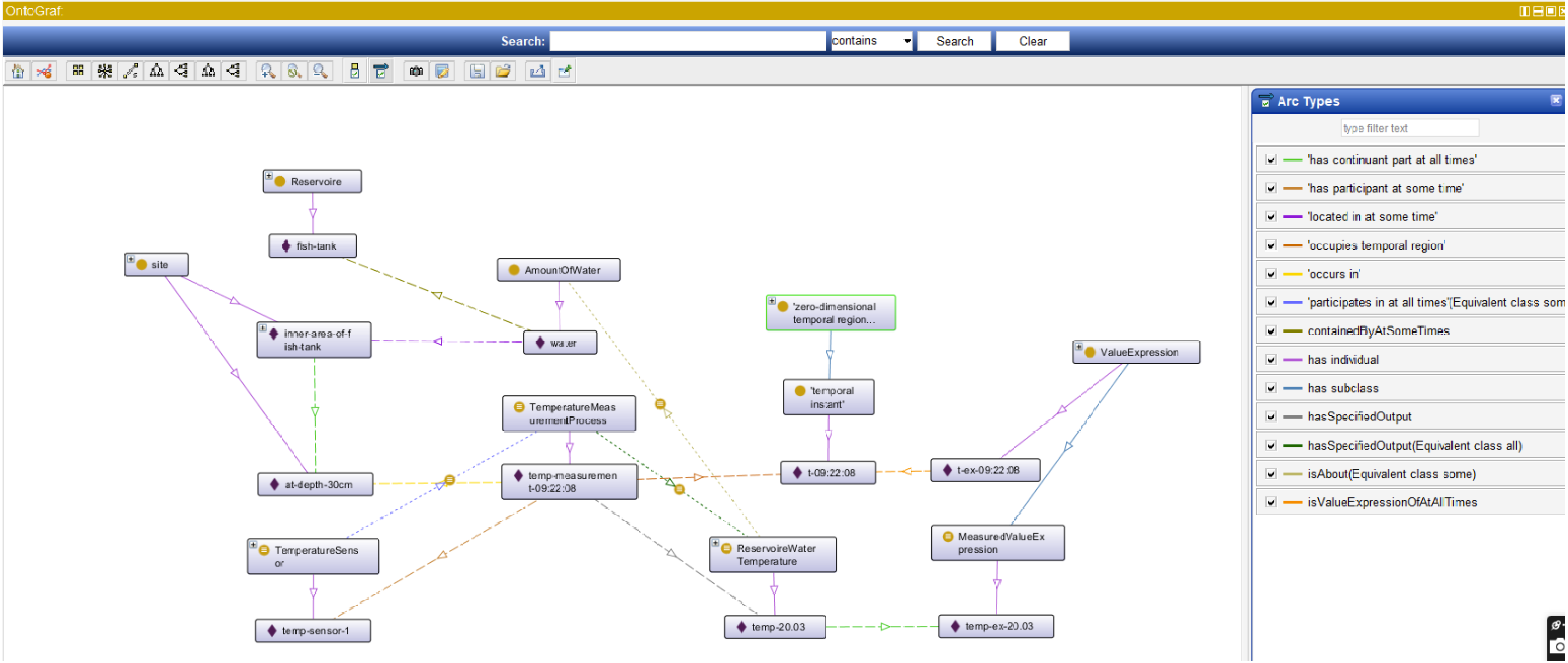
Details | Instances (0) | Visualization | Notes (0) | Class Mappings (3) | Access Class JSON

Preferred Name	manufacturing process
Definitions	planned process that consists of a structured set of operations through which input material is transformed or modified into another material entity Manufacturing Process x implies x is a Planned Process that 'has input' some 'material entity' m and 'has specified output' y which is a Material Artifact or a 'material entity' that is 'prescribes by' some Design Specification d and x 'has participant at some time' some Machine or Person z that is the 'carrier of' some Plan Specification p that prescribes x ManufacturingProcess(x) → PlannedProcess(x) ∧ ∃m,∃y,∃p,∃z (MaterialEntity(m) ∧ (MaterialArtifact(y) ∨ ∃d(MaterialEntity(y) ∧ DesignSpecification(d) ∧ prescribes(d,y)) ∧ PlanSpecification(p) ∧ prescribes(p,x) ∧ (Person(z) ∨ Machine(z)) ∧ isCarrierOf(z,p) ∧ particiaptesInAtSomeTime(z,x) ∧ isInputOf(m,x) ∧ hasSpecifiedOutput(x,y)) 1. Structured set of activities or operations performed upon material to convert it from the raw material or a semifinished state to a state of further completion. [ISO 15531-1,ISO 15531-43:2006(en)] 2. Series of operations performed on material to convert it from a raw material or a semifinished state to a state of further completion. Manufacturing processes can be arranged in a process layout, product layout, cellular layout, or fixed-position layout. Manufacturing processes can be planned to support make-to-stock, make-to-order, assemble-to-order, and so forth, based on the strategic use and placement of inventories [APICS & ISO 15531-43]. 1. This definition presupposes that the outputs of a manufacturing process are in every case material artifacts or man-made substances. 2. Processes that have as their primary output, something immaterial or informational in nature (digital outputs), such as found in the production of software, will be considered speparately at a later stage. 3.. There are other processes that while they may come into direct contact with a manufactured component or substance and are often considered part of the overall set of activities planned and executed to manufacture something, they are not "transformative" in nature relative to that which is manufactured, and are specifically excluded the definition. Examples include setup, tear down, transporting components or materials between locations, inspection, and so forth. This is addressed by output in the axiom. Setup => does not have output. Tear down like disassembly should still be considered transformative. 4. This definition places no additional restrictions on the output of a manufacturing process in terms of being in a state of completion (completed component or finished good).
ID	https://purl.industrialontologies.org/ontology/core/Core/ManufacturingProcess
comment	1. This definition presupposes that the outputs of a manufacturing process are in every case material artifacts or man-made substances. 2. Processes that have as their primary output, something immaterial or informational in nature (digital outputs), such as found in the production of software, will be considered speparately at a later stage. 3.. There are other processes that while they may come into direct contact with a manufactured component or substance and are often considered part of the overall set of activities planned and executed to manufacture something, they are not "transformative" in nature relative to that which is manufactured, and are specifically excluded the definition. Examples include setup, tear down, transporting components or materials between locations, inspection, and so forth. This is addressed by output in the axiom. Setup => does not have output. Tear down like disassembly should still be considered transformative. 4. This definition places no additional restrictions on the output of a manufacturing process in terms of being in a state of completion (completed component or finished good).
counter example	statistical process control and preventative maintenance management processes that maximize machine availability and the product quality of manufactured products.
example	Drilling a hole on an engine block; manufacturing operation for making a shaft consisting of milling, turning, and drilling manufacturing processes; assembly process, and quality control process; a manufacturing process that uses 3D printing to create the output material entity.
first order logic definition	ManufacturingProcess(x) → PlannedProcess(x) ∧ ∃m,∃y,∃p,∃z (MaterialEntity(m) ∧ (MaterialArtifact(y) ∨ ∃d(MaterialEntity(y) ∧ DesignSpecification(d) ∧ prescribes(d,y)) ∧ PlanSpecification(p) ∧ prescribes(p,x) ∧ (Person(z) ∨ Machine(z)) ∧ isCarrierOf(z,p) ∧ particiaptesInAtSomeTime(z,x) ∧ isInputOf(m,x) ∧ hasSpecifiedOutput(x,y))
label	manufacturing process
natural language definition	planned process that consists of a structured set of operations through which input material is transformed or modified into another material entity
prefixIRI	iof-core:ManufacturingProcess
prefLabel	manufacturing process
semi-formal natural language definition	Manufacturing Process x implies x is a Planned Process that 'has input' some 'material entity' m and 'has specified output' y which is a Material Artifact or a 'material entity' that is 'prescribes by' some Design Specification d and x 'has participant at some time' some Machine or Person z that is the 'carrier of' some Plan Specification p that prescribes x
subject matter expert explanation	1. Structured set of activities or operations performed upon material to convert it from the raw material or a semifinished state to a state of further completion. [ISO 15531-1,ISO 15531-43:2006(en)] 2. Series of operations performed on material to convert it from a raw material or a semifinished state to a state of further completion. Manufacturing processes can be arranged in a process layout, product layout, cellular layout, or fixed-position layout. Manufacturing processes can be planned to support make-to-stock, make-to-order, assemble-to-order, and so forth, based on the strategic use and placement of inventories [APICS & ISO 15531-43].
	https://purl.industrialontologies.org/ontology/core/Core/PlannedProcess

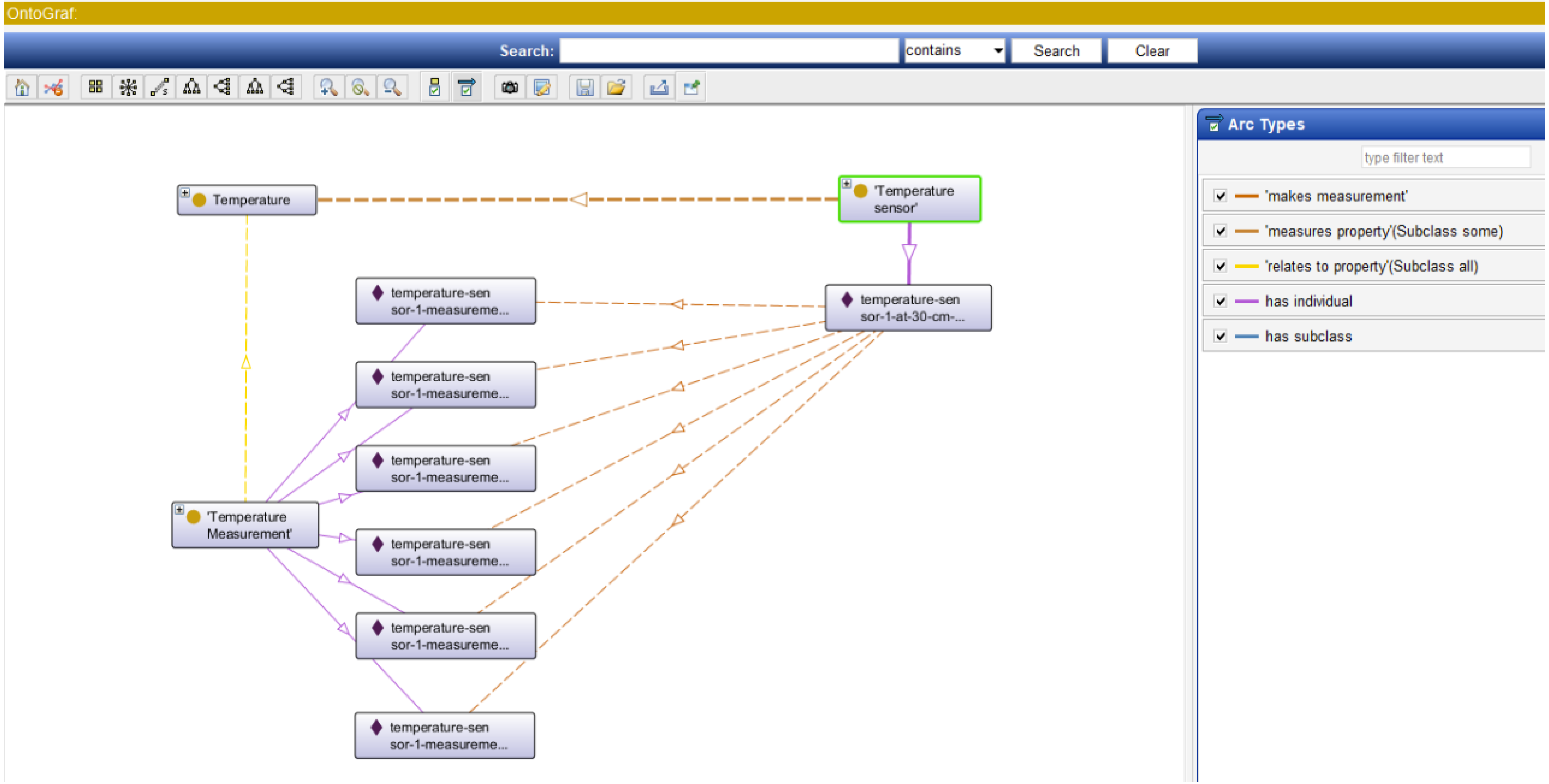
Documenting data with ontology

- From CSV, Excel, or other flat files
  - OntoRefine
- From database (RDBMS)
  - KGCreator, R2RML, RML, YARRRML
- From complex structure (JSON, XML)
  - XSPARQL
- Generic, customizable
  - SPARQL, along with Jena, RDFLib, OWLReady, OntoPy

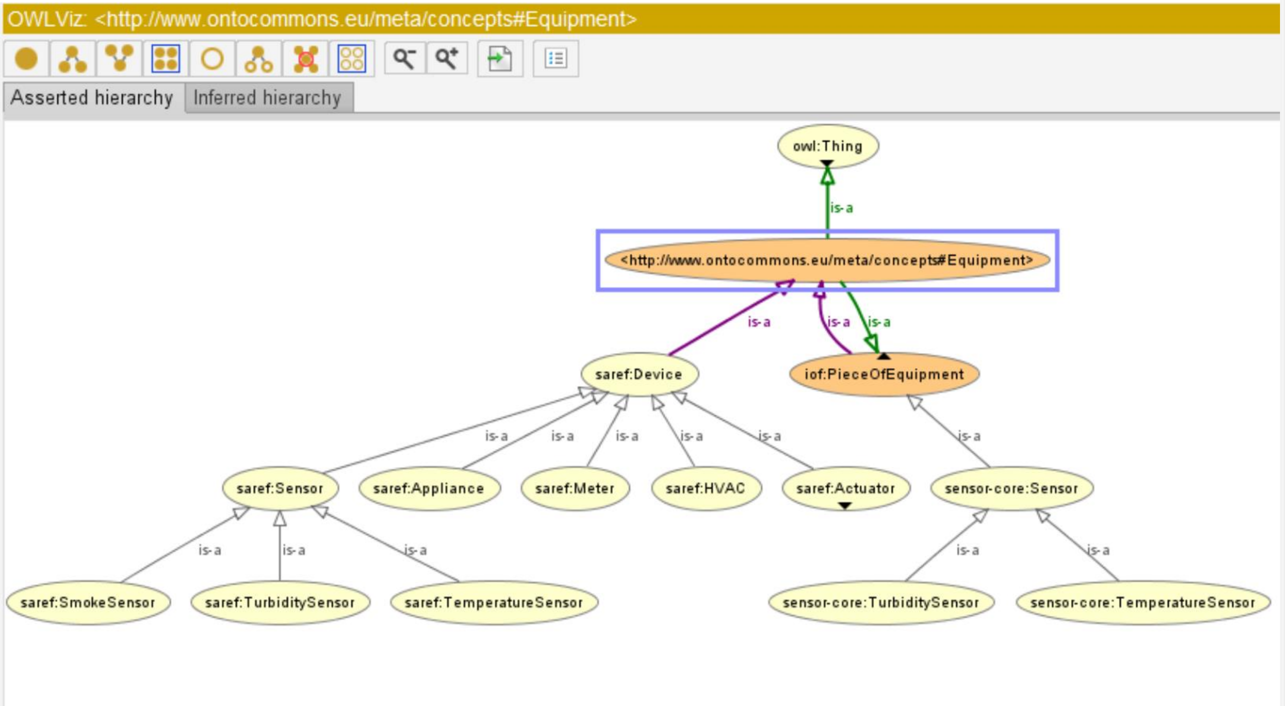
Sensor data modeled in IOF-Core

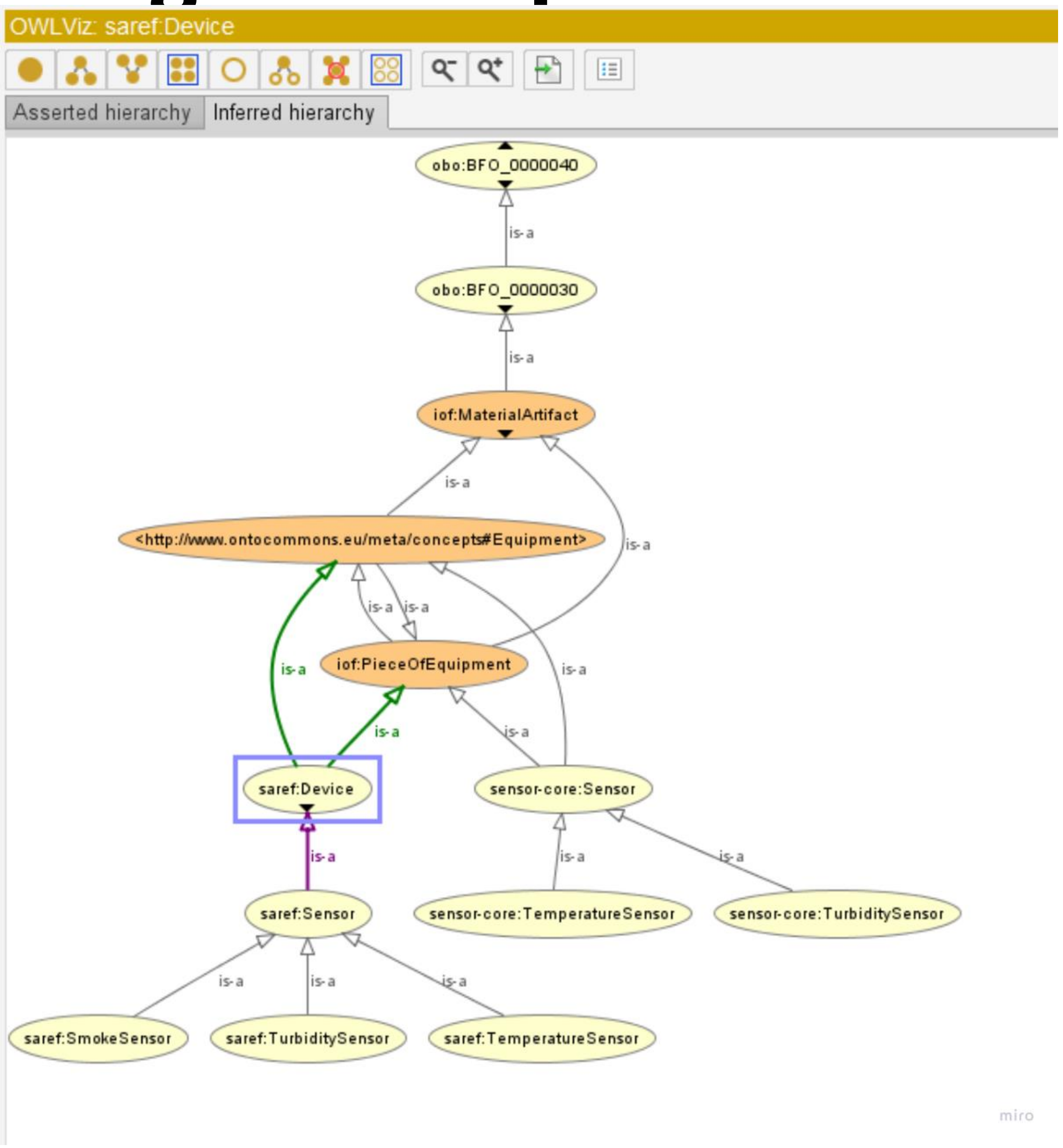


Sensor data modeled in SAREF



Alignment using bridge concepts





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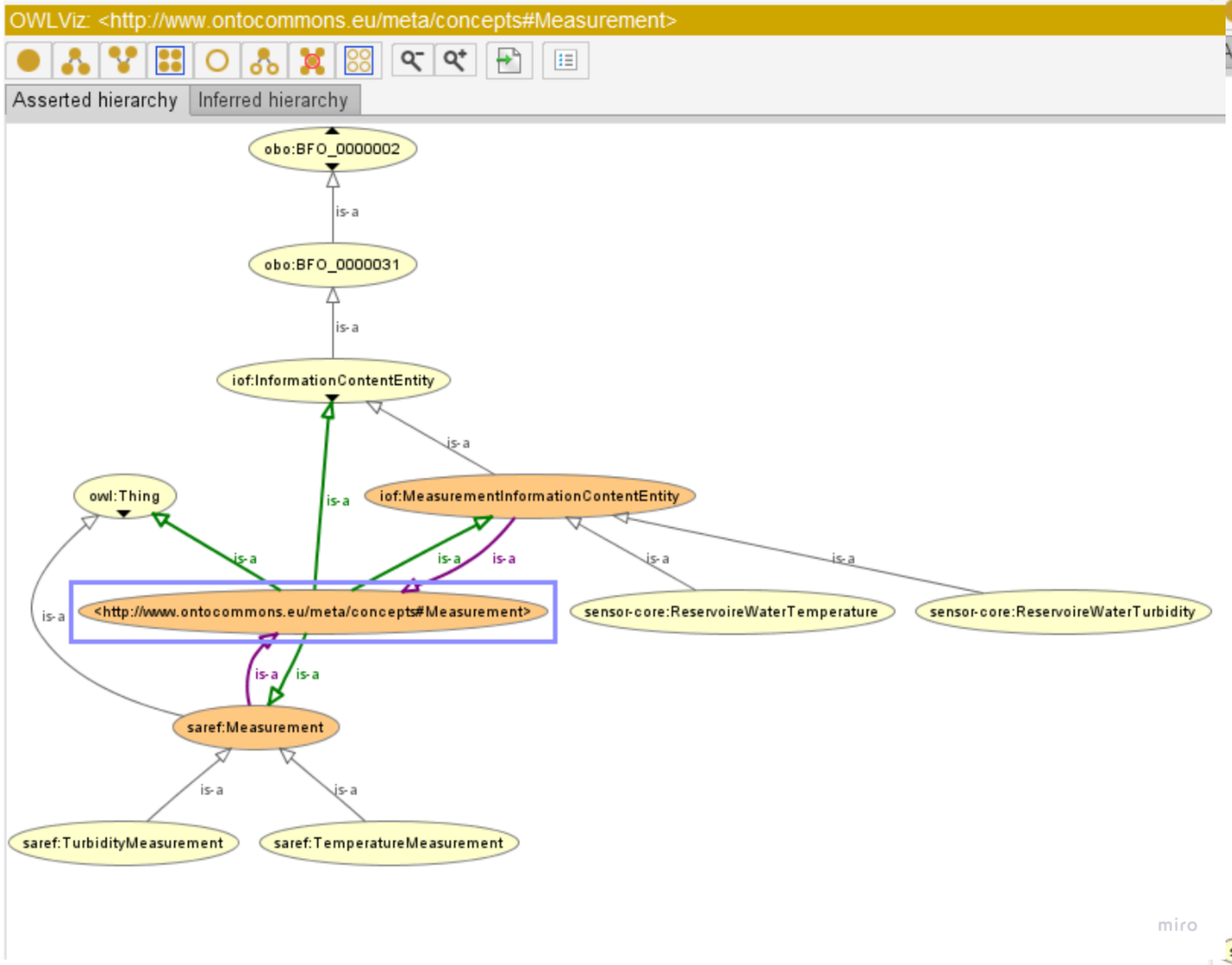
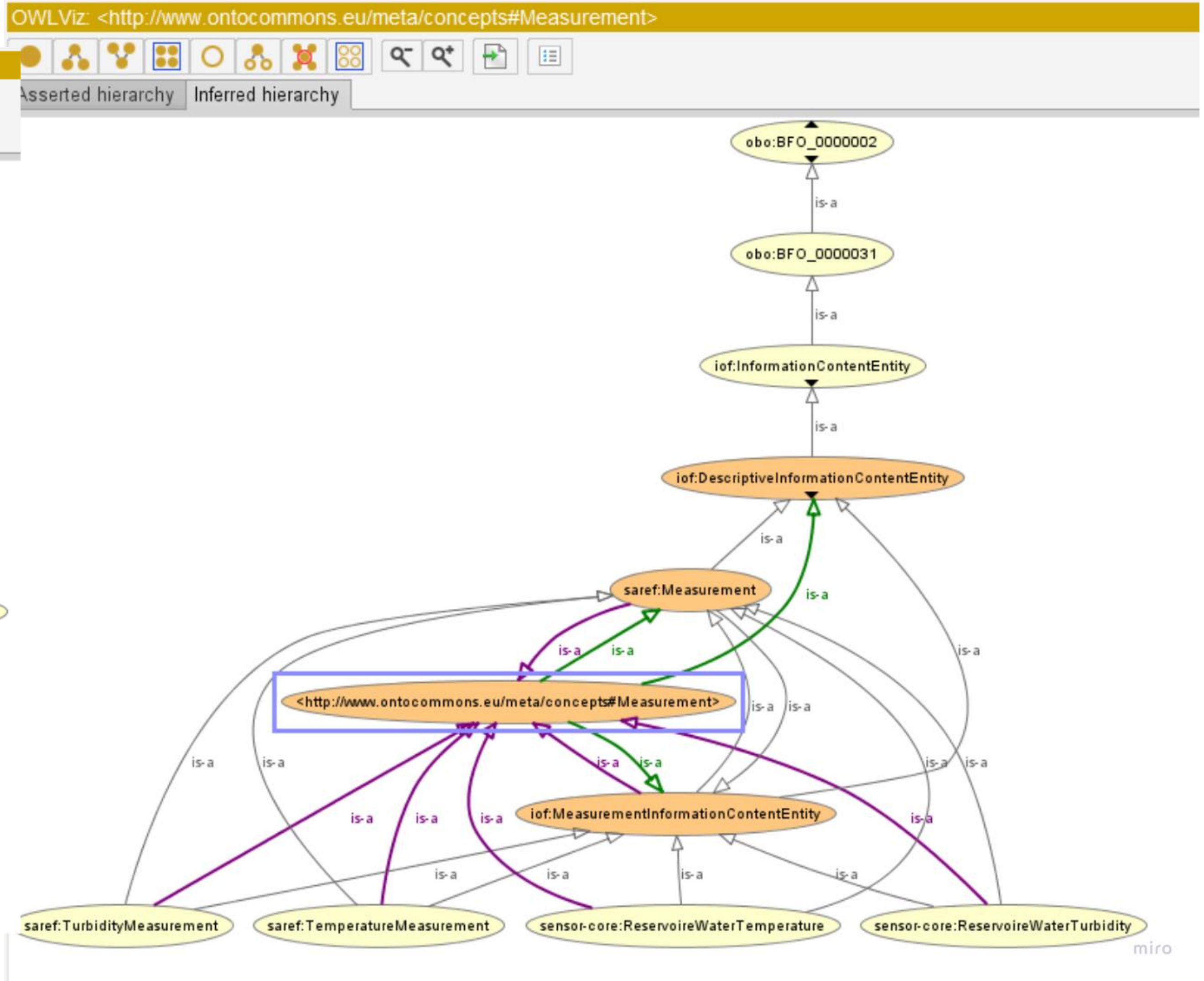
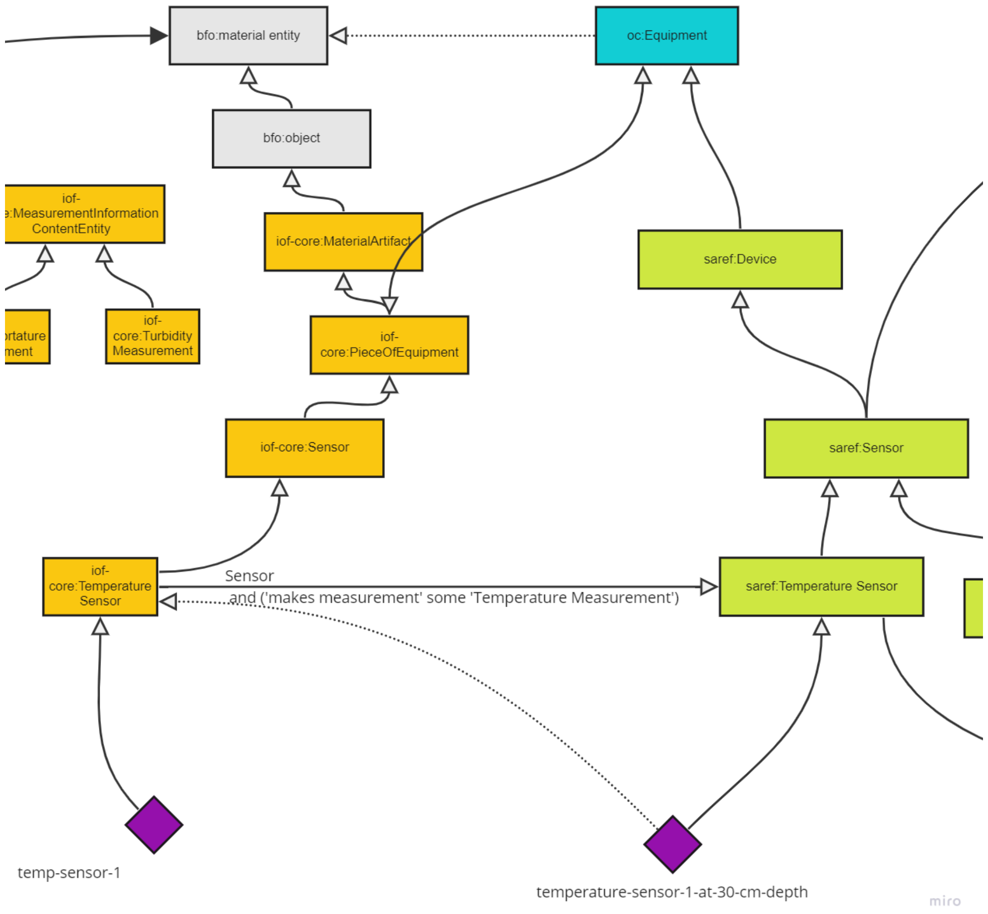
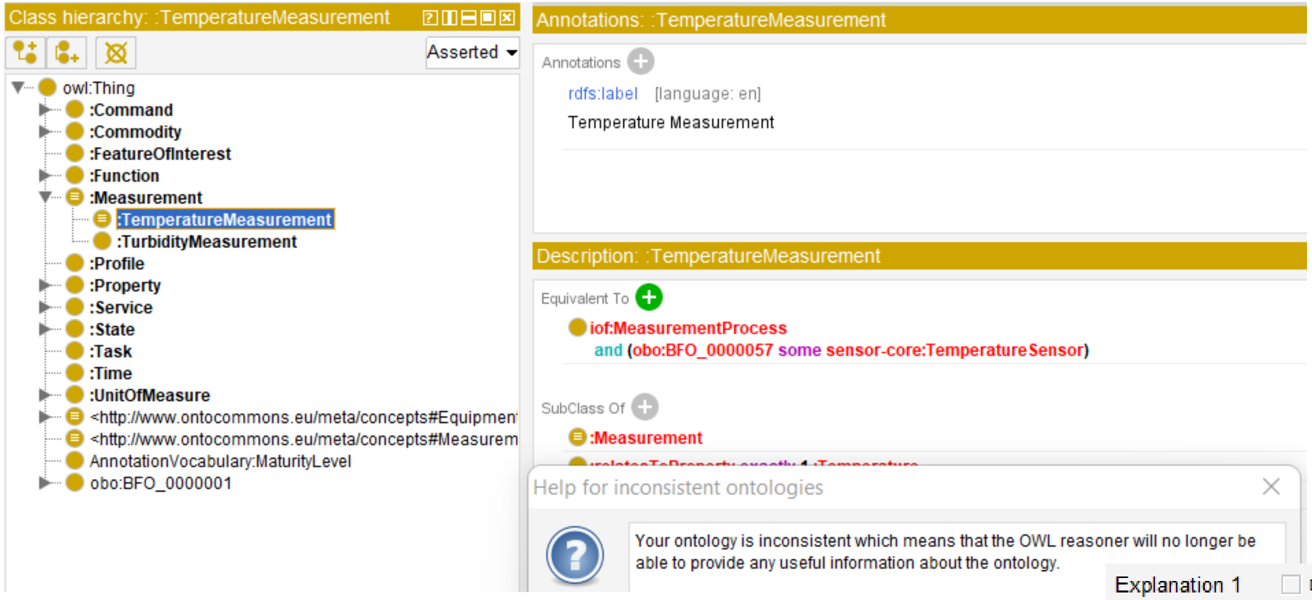


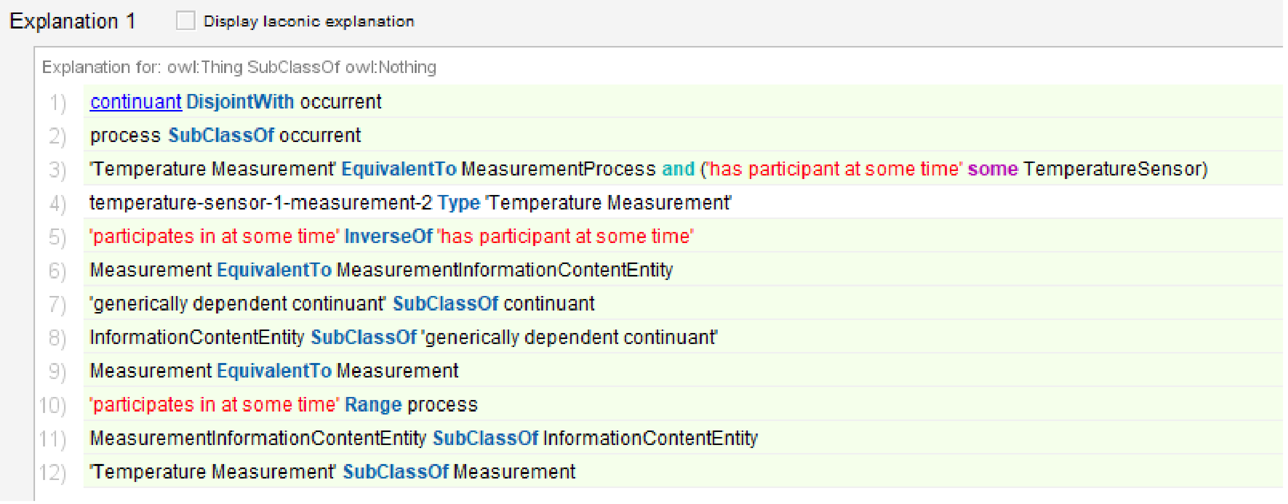


Data interoperability through ontology alignment



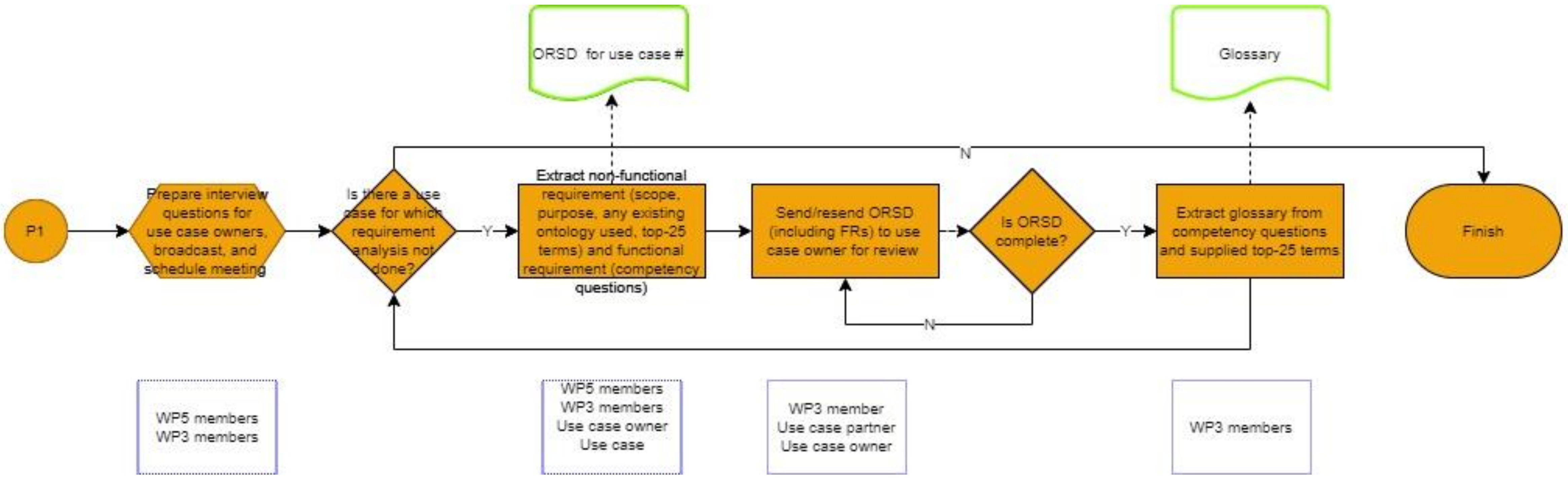
How bridge concept prevents misalignment





Requirement Engineering
for OntoCommons Industrial Partners

Requirement gathering from partners



ORD template

	A	B
1		**Ontology Requirements Specification Document**
2	**1**	**Purpose (mandatory)**
3		The primary goal of the use case is to reduce the number and size of, and time required for experiments, for identifying the behaviour of a material or combination of them (e.g., metal, coating, lubricant) with respect to specific operating conditions. The goal is planned to be achieved via better representation of material experiments, enriching existing data with additional background knowledge, easing data retrieval and navigation through related resources.
4	**2**	**Scope (mandatory)**
5		The use case will provide ontology-based access to a materials' tribological-related information to abstract from underlying data structures.
6	**3**	Implementation Language and existing standards and ontologies
7		TribAln ontology (TribAln 2.0), EMMO / EMMC, VAR Ontology
8	**4**	Intended End-Users
9		Tribological expert, Ontology engineer/Semantic technologies expert, Software developer
10	**5**	Intended Uses
11		We should be able to have an API to query the information of experiments. The information would be represented with adequate ontology terms, but the API would abstract the end-user from the necessary underlying SPARQL queries.
12	**6**	Non-Functional Requirements
13		The goal is planned to be achieved via a common representation of material tribological experiments.
14		Enriching existing data with additional background knowledge
15		1. **Functional Requirements: Lists or tables of requirements written as Competency Questions and sentences**
16		
17	**7**	**Pre-Glossary of Terms (optional)**
18		1. **Terms from Competency Questions**

Sample data/ Testing/ Benchmarking

- How to collect sample data?
  - Confidentiality, Security
  - Ontocommons procedure and policies
- How to publish FAIR data with semantic annotation
- Evaluation and benchmarking

Thanks

Questions?

FOLLOW US ON

Contact

www.ontocommons.eu

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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