



EC Materials and Manufacturing Ontology workshop

Brussels, 06.06.2019



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1. Your name and name of your taxonomy and/or ontology

■ European Virtual Marketplace Ontology - EVMPO

VIMMP
VIRTUAL MATERIALS
MARKETPLACE

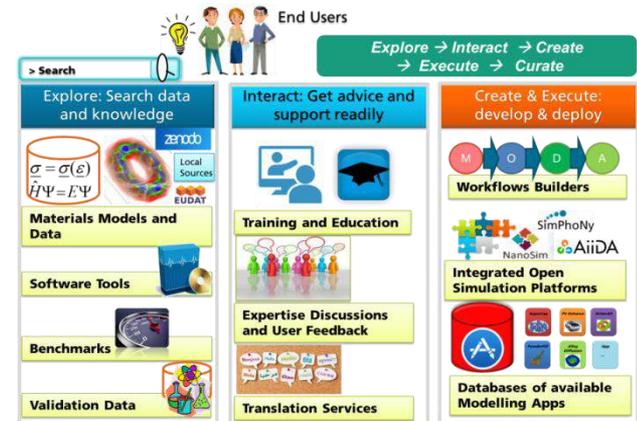
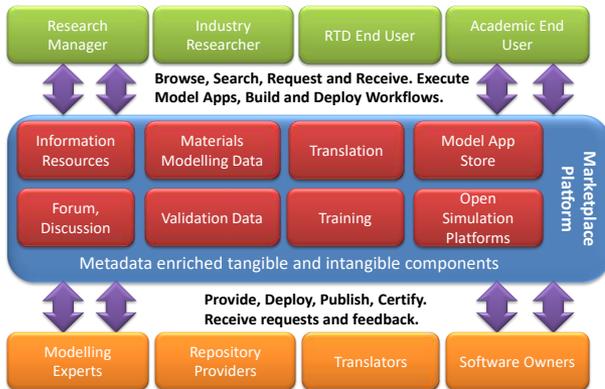
www.vimmp.eu
(GA 760907)

MarketPlace

<http://The-marketplace-project.eu>
(GA 760173)

2. What is the application domain of your taxonomy and/or ontology?

- Online European Materials Modelling Marketplace Framework with two IA projects:
 - Virtual Materials Marketplace (VIMMP) and
 - Materials Modelling Marketplace for increased industrial innovation (MarketPlace)
- Interoperable platforms
- Prospective attached service components, including:
 - Open translation environments
 - Repositories for expertise, educational services, materials models, relations, training, ...





3. What is the intended purpose of the taxonomy and/or ontology? (Taxonomies are used for data documentation, while ontologies add the possibility of extended reasoning)

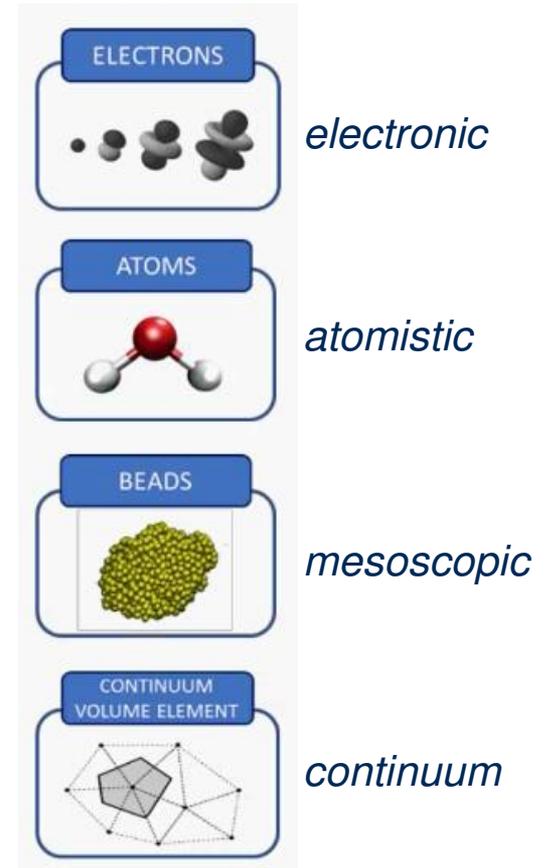
- Interoperability between the platforms
 - Goal is not to lock users to one implementation,
 - Facilitate interoperability on services levels → added value for users and customers
- In practice, we use a shared upper ontology to
 - Structure data at web and front and back ends on the marketplace platforms
 - Build libraries to translate data for specific services
 - Facilitate semantic technology operating at marketplace platforms
 - Enable integration of materials models from repositories into workflows and platforms
 - Interoperability between repositories, open translation environments, and other hosted services and components

4. How do you represent the world?

We adopt the granularity vision of the Room, CWA and EMMO.

RoMM: Reviews of Materials Modelling, What makes a material function? Let me compute the ways..., Anne F. de Baas (ed), 6th version, 2017.

EMMO: European Materials Modelling Ontology, E. Ghedini et al., in development.





5. What are the concepts, with definitions, in the upper level of your taxonomy and/or ontology?

• European Virtual Marketplace Ontology - EVMPO

The EVMPO provides a structure for the marketplace-level ontologies by formulating **fundamental paradigmatic categories** that correspond to irreducible terms which are seen as constitutive to the virtual-marketplace paradigm.

Recommendation: Any ontology at the marketplace level should follow the structure given by these categories as closely as possible

Fundamental paradigmatic categories:

- 1. assessment**, i.e., proposition on accuracy, performance of an entity, or of an entity's trust in another entity
- 2. calendar_event**, i.e., meeting or activity that is scheduled or can be scheduled, equivalent to Vevent from ICALTZD
- 3. communication**, i.e., statement or sequence of statements that can be communicated at a virtual marketplace
- 4. information_content_entity** as defined in the Information Artifact Ontology (IAO)
- 5. infrastructure**, i.e., virtual-marketplace infrastructure (e.g., data access, hardware, and software)
- 6. material** as defined in the European Materials Modelling Ontology (EMMO)
- 7. model**, i.e., entity that can be described by the 2nd section of MODA, equivalent to "model" from the EMMO
- 8. process**, i.e., temporal evolution of one or multiple entities
- 9. product**, i.e., good or service that can be offered either at a virtual marketplace or off-site
- 10. property** as defined in the EMMO
- 11. role** as defined in the EMMO
- 12. simulation**, i.e., a simulation workflow (as in MODA)

6. What are the industrial use cases (e.g. in ontology-driven tools) demonstrating the value of the taxonomy and/or ontology?

- Industrial Application Fields
 - Additive manufacturing
 - Screen printing processes
 - Ceramic injection molding
 - Nano-based catalysis systems
 - Materials for photovoltaic cell printing
 - 3D printing of metals
- CO: Adham Hashibon (Fraunhofer IWM)
- Ontology development beyond EVMPO:
 - All partners lead by A. Hashibon, Gerhard Goldbeck, Heinz Preisig, Georg Schmitz, Jesper Friis, ...



6. What are the industrial use cases (e.g. in ontology-driven tools) demonstrating the value of the taxonomy and/or ontology?

- Industrial Applications: Soft matter based materials

- Examples of use cases:

- Emulsions - food emulsions
- Complex/structured fluids - personal care liquid
- Polymer composites – tire compounds
- Corrosion inhibitors - Polymer corrosion inhibitors in metalworking fluids and paints & coatings

- CO: Welchy L. Cavalcanti (Fraunhofer IFAM)

- Ontology development beyond EVMPO:

- Work lead by STFC partners in VIMMP:

Martin Thomas Horsch, Silvia Chiacchiera, Ilian Todorov and Michael Seaton.
(Contact: martin.horsch@stfc.ac.uk , silvia.chiacchiera@stfc.ac.uk)





Note on rest of questions: marketplace-level ontologies will be consistent with the EMMO

- Questions 7-15 largely follow the same principles of the EMMO
- In other words: both marketplace IA projects develop various branches under the umbrella of EMMO!
- Hence, next slides comprise work in progress from both marketplace IA projects; the aim is to converge and to be aligned with the EMMO.



7. What overlaps do you see with other taxonomy and/or ontologies?

- EVMPO may have overlap with other ontologies of services, example manufacturing.
- EVMPO is WIP and we are building in each project additional components, too early to determine.

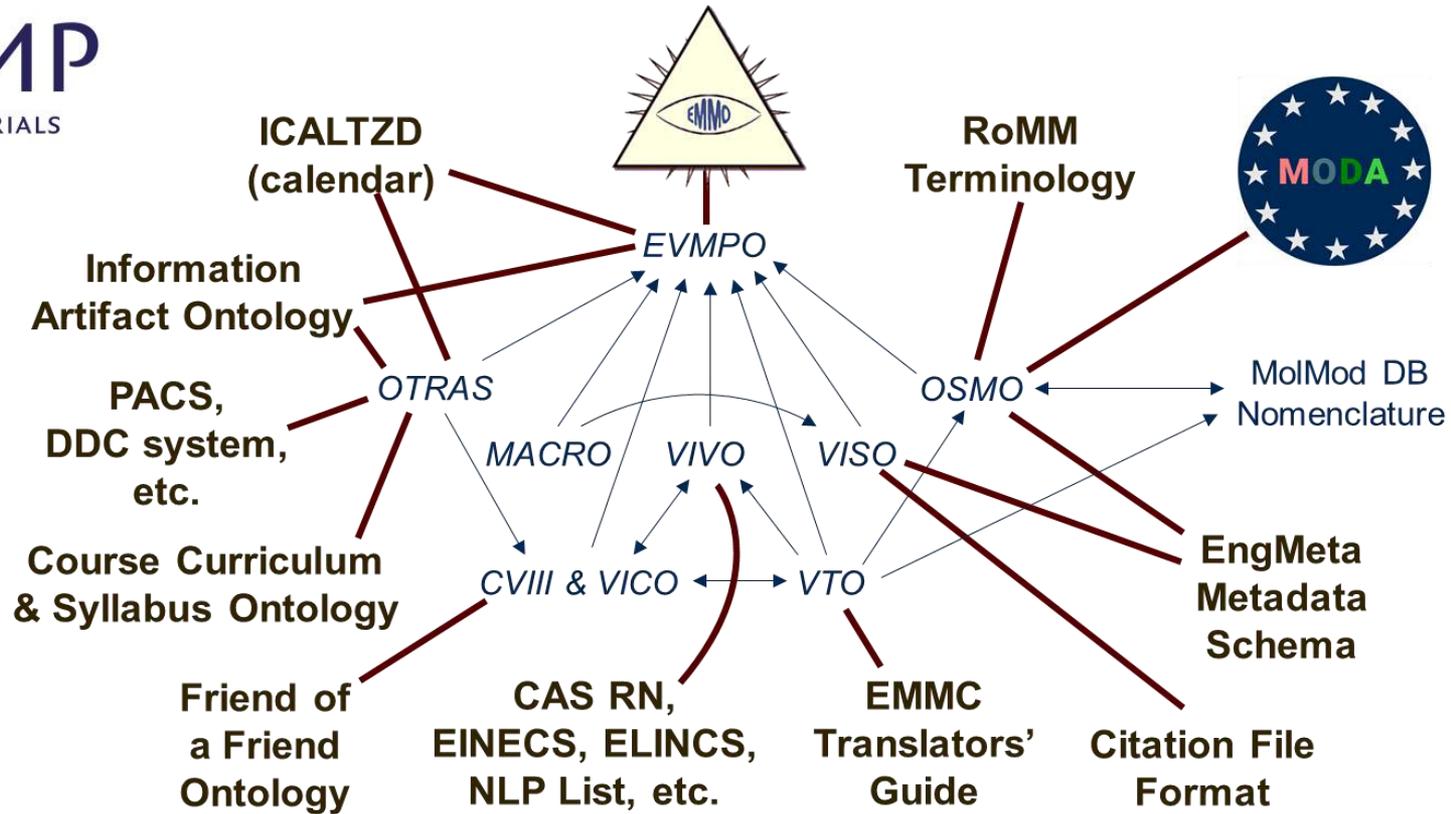




7. What overlaps do you see with other taxonomy and/or ontologies?



VIMMP
VIRTUAL MATERIALS
MARKETPLACE



Blue: Own semantic assets

Black: Related external semantic assets with an overlap or interaction

8. What are the (main) relations in your ontology?

- Has-a relations and sub relations
- Similar to EMMO but with respect to the services represented in EVMPO



8. What are the (main) relations in your ontology?



Ontology metrics:	
Metrics	
Axiom	4393
Logical axiom count	3134
Declaration axioms count	901
Class count	1007
Object property count	147
Data property count	56
Individual count	328
Annotation Property count	3

The European Virtual Marketplace Ontology, and the marketplace-level ontologies connected to it, define over 200 relations between objects and objects (owl:ObjectProperty) and between objects and elementary data (owl:DatatypeProperty).

The paradigm inherited from the European Materials Modelling Ontology distinguishes three main types of object properties:

- **membership** (set theory)
 - **representation** (semiotics)
 - **parthood and slicing** (mereotopology)

9. What is the knowledge your specific ontology represents?

- a. Knowledge necessary for a pragmatic description of current practices, or
 - b. Explanation of the world according to one of the philosophical views called realism/conceptualism/nominalism
-
- We follow a straightforward approach without any wish to enter into philosophical discussions of the world. In this particular sense, the approach might be called “pragmatic”.

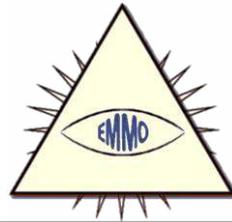


Intended Purpose (Summary from both projects)

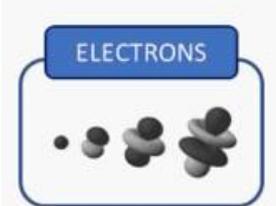
- Representation of services and user management
- Computational **representation** of top-down and bottom-up workflows including the user case and all computational details and GUI elements
- Wrapper development
- Dataspaces
- Marketplace services
- Integrated materials modelling workflows
- Coupling and Linking
- Characterisation
- Manufacturing processes (as much as needed for the demonstrators)



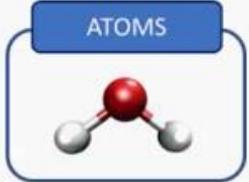
10. How does your ontology represent the relations between different granularity views on the same object?



■ We implement the EMMC approach based on RoMM, MODA, and EMMO. The VIMMMP and Marketplace will connect all granularity levels.



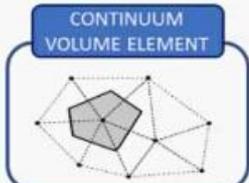
electronic



atomistic



mesoscopic



continuum





11. How does your ontology represent materials?

- Following EMMO
 - Using granularity
 - State
 - Parthood relations (mereotopology)

12. What type of processes do you address? How does your ontology represent these processes?

- The entire process of running the marketplace services, e.g.,
 - Translation process
 - Simulation workflow as a process (moda and external moda shells)
- Manufacturing processes – very limited set relevant to the demonstrators



12. What type of processes do you address? How does your ontology represent these processes?



- The word “process” can have multiple meanings; here, we apply the EMMO definition
- Additionally some examples:
 - Physical properties related to transport processes are dealt with as physical properties
 - Business and production processes may be dealt with by future work on the Translation Services and workflows VIMMP Ontology (VTO)
 - Simulation workflows (processes of conducting simulations) are formalized by Ontology Version of MODA (OSMO)
 - Interaction processes between participants at virtual marketplaces are described by VIMMP Communication Ontology (VICO)
 - Processes by which a person learns, i.e., undergoes a training process, are characterized by OTRAS on the basis of the Course Curriculum and Syllabus Ontology



13. How does your ontology represent manufacturing?

- Manufacturing processes – very limited set relevant to the demonstrators
- User interaction and operation as a set of processes
- The ontology includes states and changes or transformations related to them
- State → process step → (New or updated) State(s)
→ process step → (New or updated) State(s)
– Still WIP



14. How does your ontology address the circular connection between physical properties, materials models (see definition in RoMM Review of Materials Modelling VI) and measurement? Domains

- The MARKETPLACE project covers also ontologies for:
 - Mathematical formulas
 - Processes
 - Databases
 - Materials relations, Models, solvers,
 - Material digital representation, characterisation, processing and manufacturing steps related to the industrial application field covered in the project
 - Homogenisation, localisation and coupling and linking
 - Databases
 - API elements (common API)
 - Workflow processes
 - Translation
 - IP protection <http://the-marketplace-project.eu> - Start 1.1.2018
 - User management





14. How does your ontology address the circular connection between physical properties, materials models (see definition in RoMM Review of Materials Modelling VI) and measurement?

- In VIMMP

- The European Virtual Marketplace Ontology contains “model” and “property” (both defined by equivalence with the respective EMMO entities) as fundamental paradigmatic categories.
- Repositories of materials models and the related semantic asset development will need to be taken into account for any virtual marketplace related to materials modelling that intends to become operative and effective.
- For instance in VIMMP, The marketplace-level ontologies from VIMMP will import and use class definitions from the European Materials Modelling Ontology, where the triangular relationship between physical properties, materials models, and experimental measurement of physical data is formalized.
- Statements on quantitative accuracy and trust in materials models, referring to their agreement with (usually phenomenologically correlated) experimental data, are dealt with by the VIMMP Validation Ontology.
- An established way of describing how physical properties are calculated by materials modelling is given by MODA. The Ontology for Simulation, Modelling, and Optimization is the ontology version of MODA, providing the required higher-level formalization.

TTL format applied to OWL DL



Terse Triple Language (TTL) consists of “triples”:

```

subject      a      class_of_subject;
              has_property      object;
              also_has_property other_object.
    
```

Example

```

osmo:logical_access a owl:Class;
  rdfs:subClassOf osmo:logical_entity;
  rdfs:comment "connection by which a logical resource is accessed"
osmo:op_logical_access a owl:Class;
  rdfs:subClassOf owl:ObjectProperty.
    
```

```

osmo:has_access_point a osmo:op_logical_access;
  rdfs:domain osmo:logical_access;
  rdfs:range osmo:moda_section.
    
```

```

osmo:has_resource a osmo:op_logical_access;
  rdfs:domain osmo:logical_access;
  rdfs:range osmo:logical_resource;
  rdfs:subPropertyOf evmpo:has_meta_annotation.
    
```

```

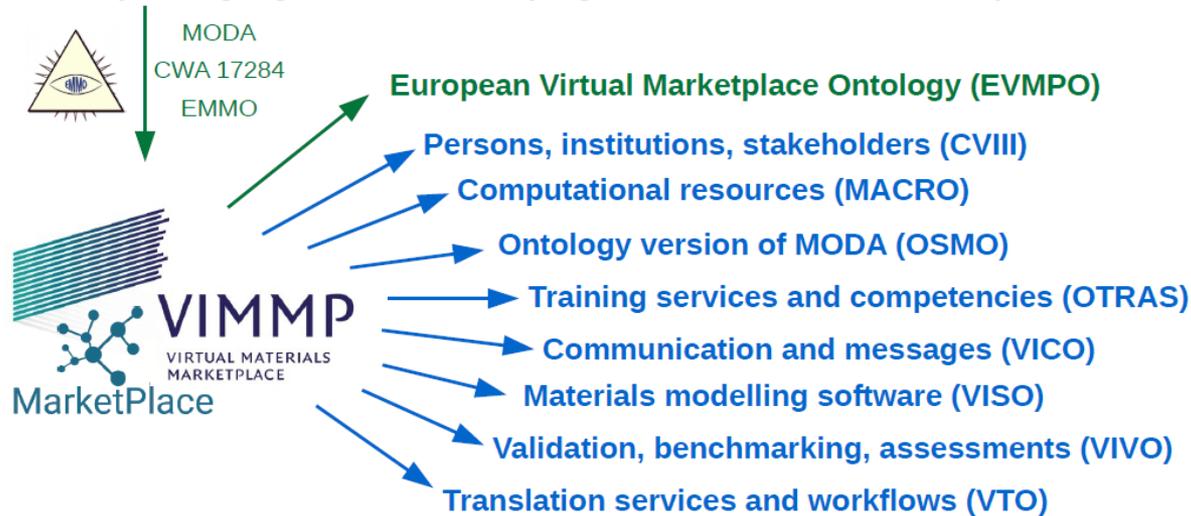
osmo:logical_access
  owl:disjointUnionOf
    (osmo:logical_read_access osmo:logical_write_access).
    
```

- Ontology for models and simulations, ontologies for services (Components such as translation, training, experts)



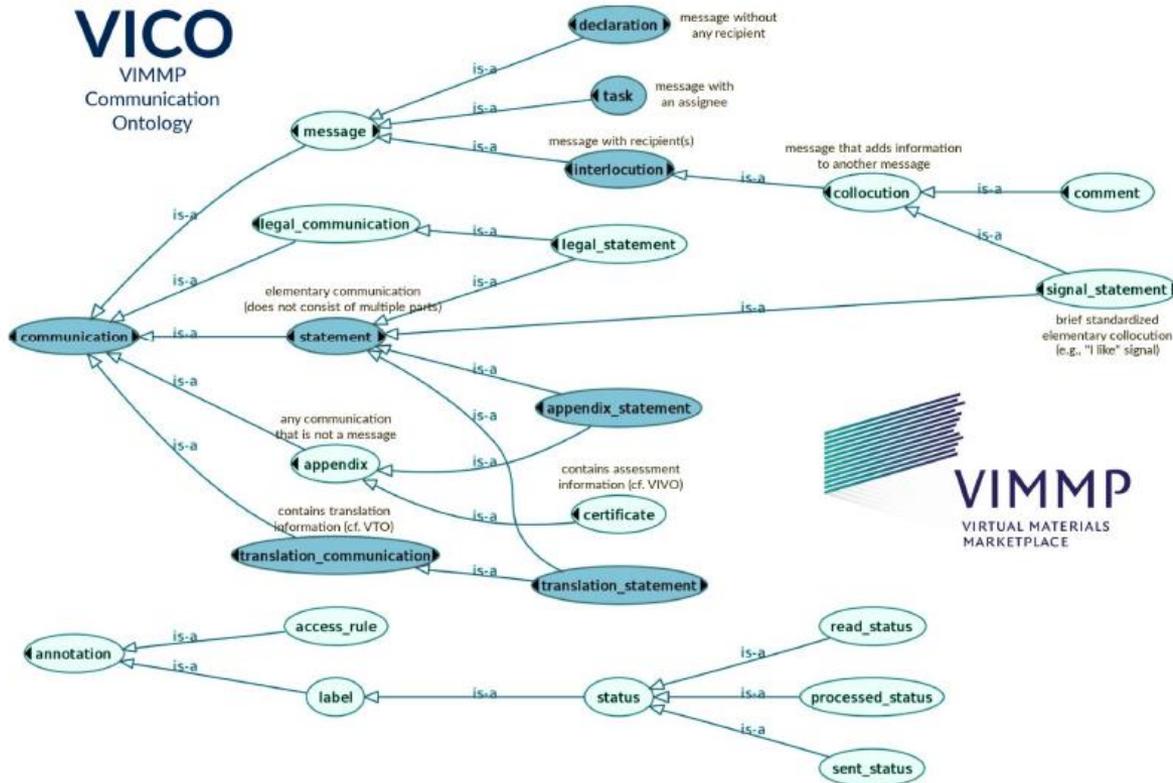
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MODA Graph Language, CEN Workshop Agreement 17284, and EMMO (Ghedini *et al.*)



- **Upper level: EMMO extended by European Virtual Marketplace Ontology (EVMPO)**
- **Marketplace-level ontologies: VIMMP in coordination with the MarketPlace project**
- **Subdomain-specific level: Modelling approaches (particle-based, continuum, ...)**

VIMMP Communication Ontology



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Virtual-marketplace stakeholder communication is formalized by VICO, taking into account specific requirements related to assessment and validation (VIVO) and translation (VTO).

Ontology for Simulation, Modelling, and Optimization



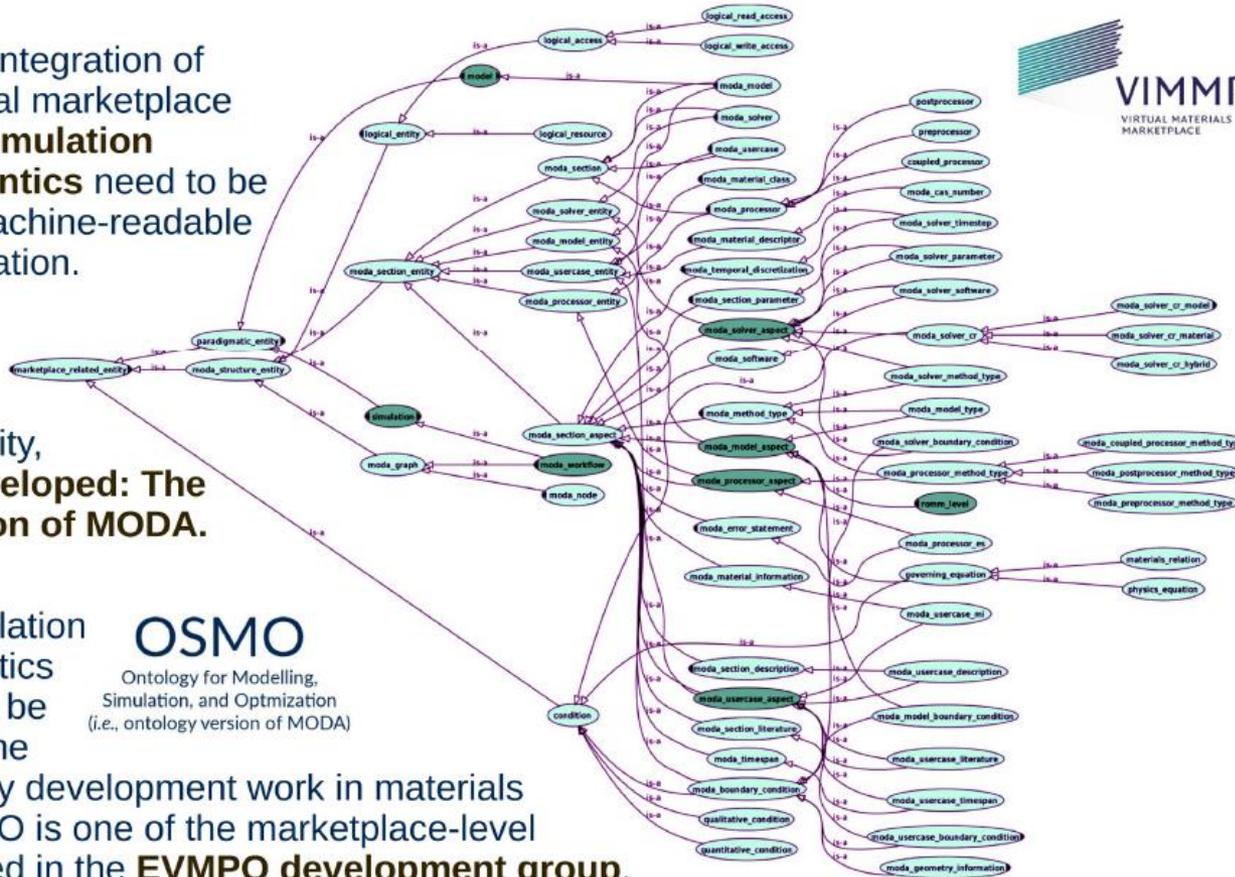
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To facilitate the integration of MODA into virtual marketplace infrastructure, **simulation workflow semantics** need to be provided at a machine-readable level of formalization.

Following the approach of the EMMC community, **OSMO was developed: The ontology version of MODA.**

By OSMO, simulation workflow semantics from MODA can be integrated into the ongoing ontology development work in materials modelling. OSMO is one of the marketplace-level ontologies shared in the **EVMPPO development group.**

OSMO
Ontology for Modelling,
Simulation, and Optimization
(i.e., ontology version of MODA)



15. What is the representation language and implementation (logics)?

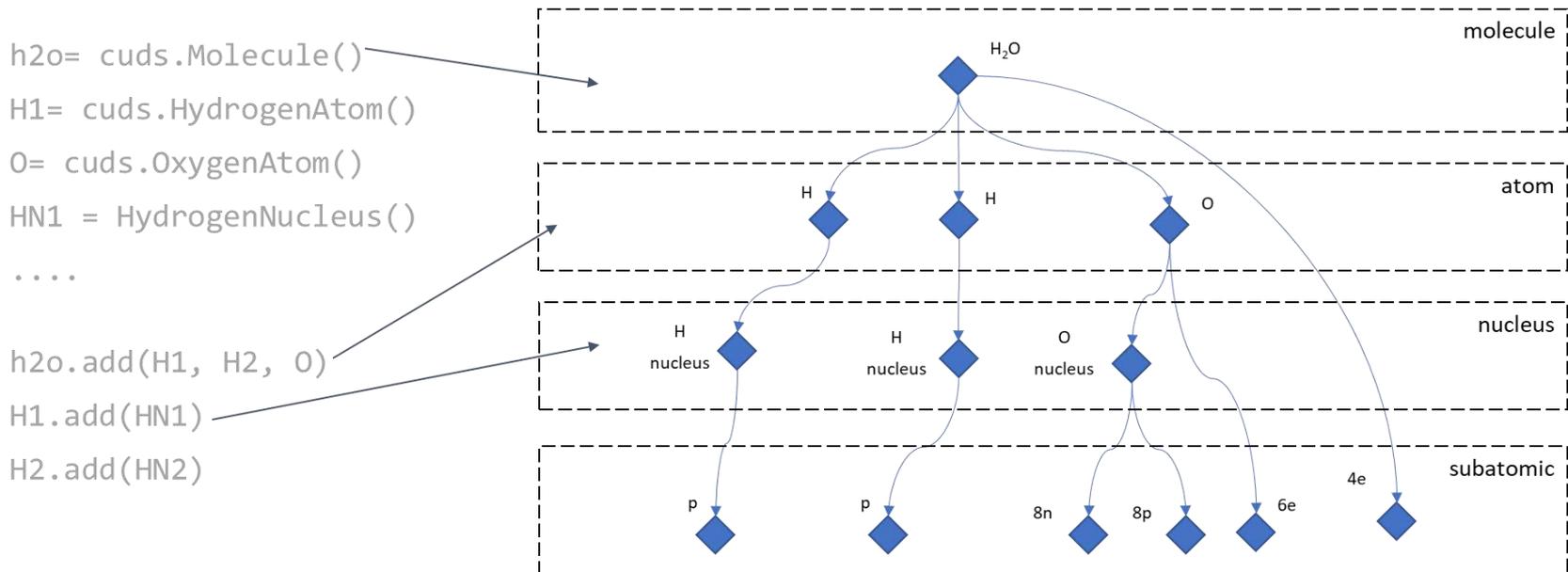
- **MARKETPLACE adopts EMMO as is and extends it to various domains relevant to the project**



- Relies on a combination of OWL DL as in EMMO
- as well as an own Ontology format combining pure ontology and data representation schemes →
 - Common Universal Data Structures (CUDS)
 - Development started in previous EU project (SimPhoNY) and continue in multiple EU actions (simDOME, REAXPRO, INTERSECT, APACHE, OYSTER, FORCE, MARKETPALCE, ...)

15. What is the representation language and implementation (logics)?

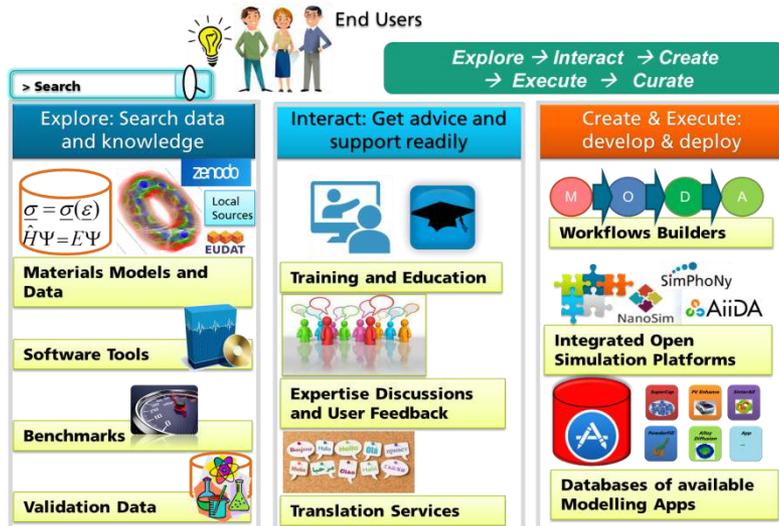
- Example of Mereotopology relation representation in EMMO-CUDS:
 - CUDS are EMMO based data containers that respect the mereotopological relations of EMMO out of the box



Materials modelling **marketplace**
for increased industrial innovation



Next generation system integration tangible and intangible
materials model components to support innovation in industry
NMBP-25-2017



<http://the-marketplace-project.eu> - Start 1.1.2018



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MARKETPLACE and VIMMP received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements No 760173 and 760907, respectively.

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Marketplace Partners



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