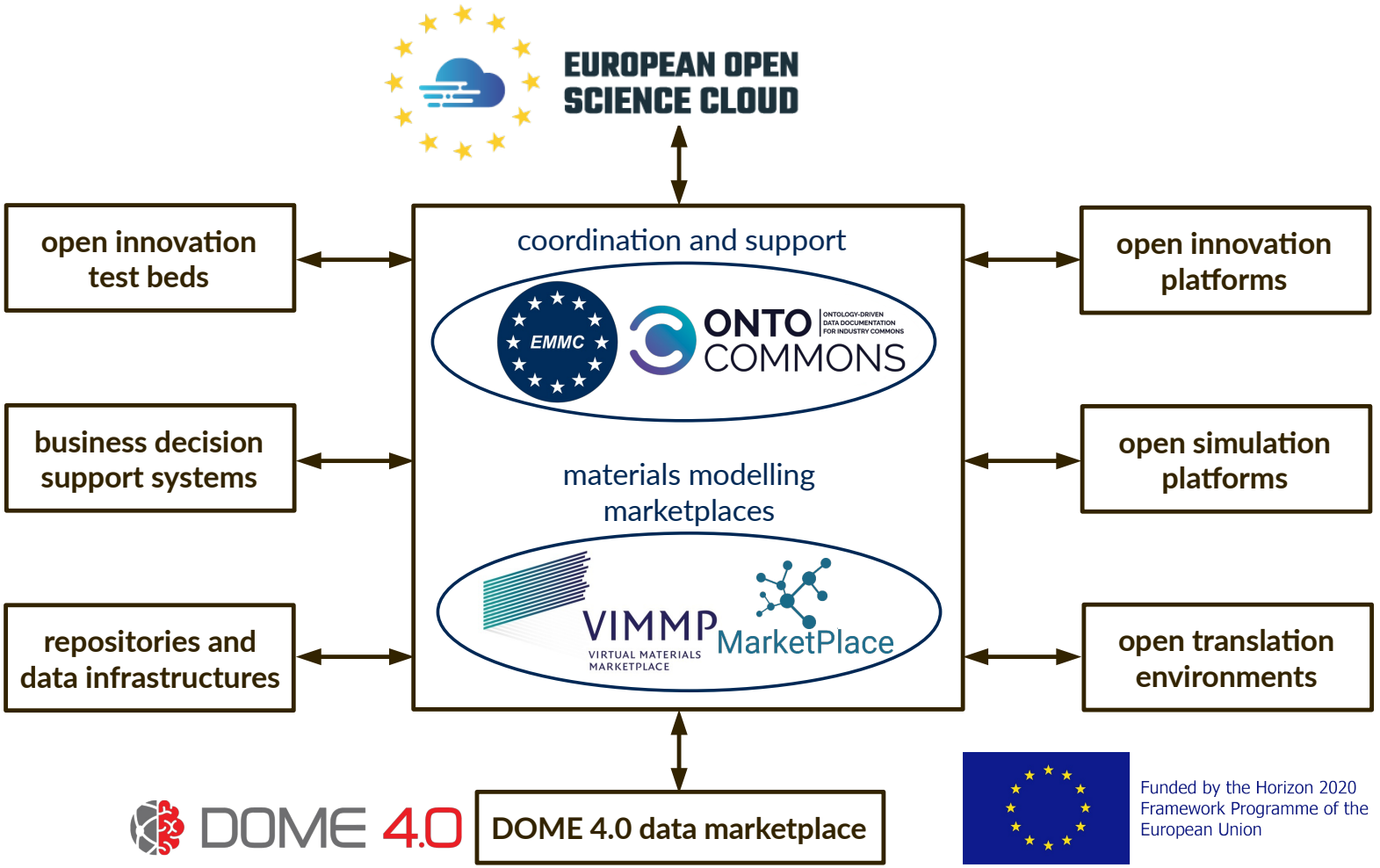
# Mereosemiotics: Parts and signs

Martin Thomas Horsch

# H2020 NMBP and EMMC ASBL metadata standardization




Funded by the Horizon 2020 Framework Programme of the European Union

# H2020 NMBP and EMMC ASBL metadata standardization

**Community-governed development of metadata standards**

**RoMM VI** → **MODA** → **CWA 17284** → **Ontologies**

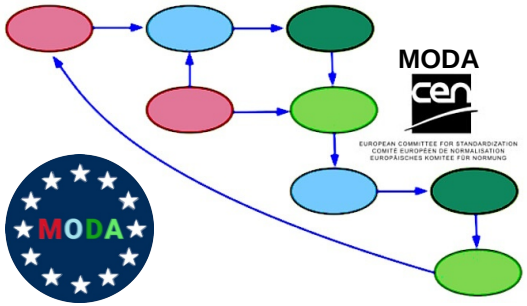
**Review of Materials Modelling (compendium)**

**MODA (Model Data) tables & graphs**

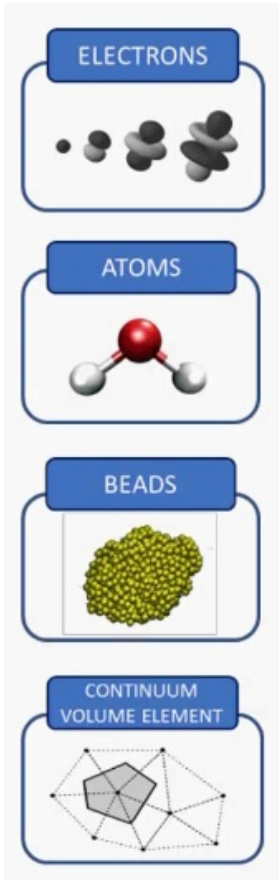
**CEN workshop agreement**

**Domain ontologies**

**EMMO top-level ontology**







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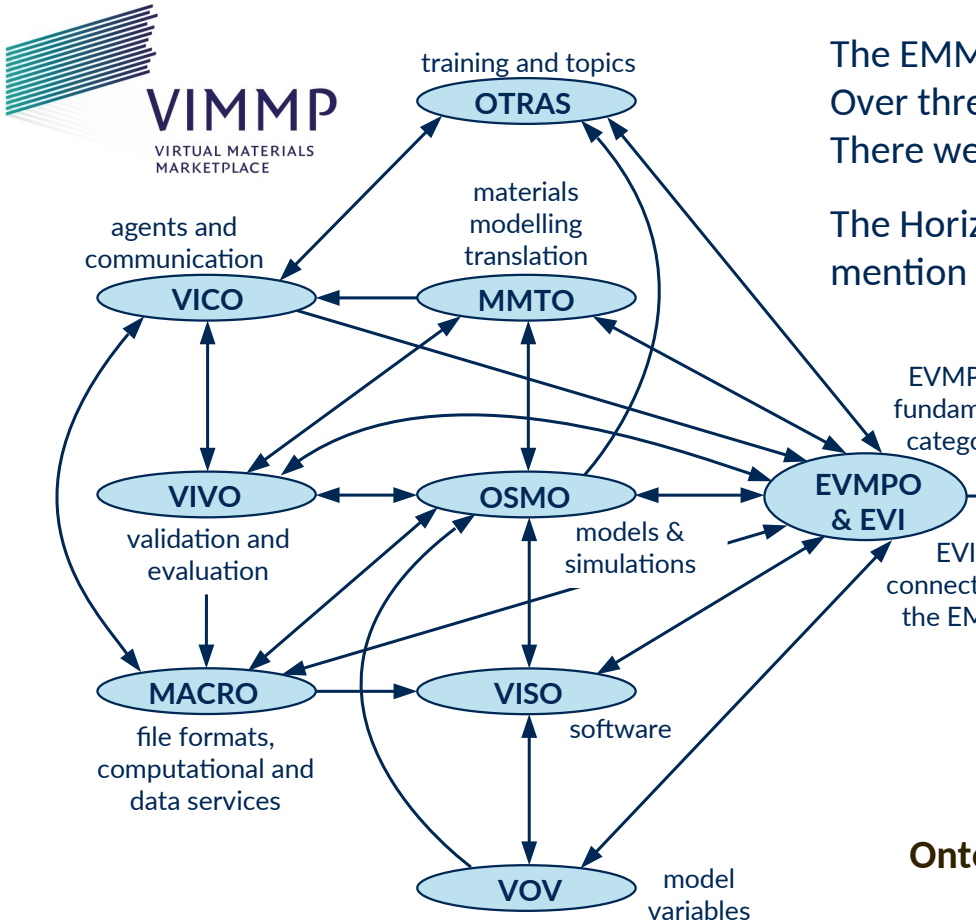



The EMMO release had been announced for mid-2018. Over three years later, there are only beta versions. There were very major changes between EMMO drafts.

The Horizon Europe CL4 work programme continues to mention EMMO compliance as a requirement.

EVMPO – fundamental categories

EVI – connection to the EMMO

EMMO

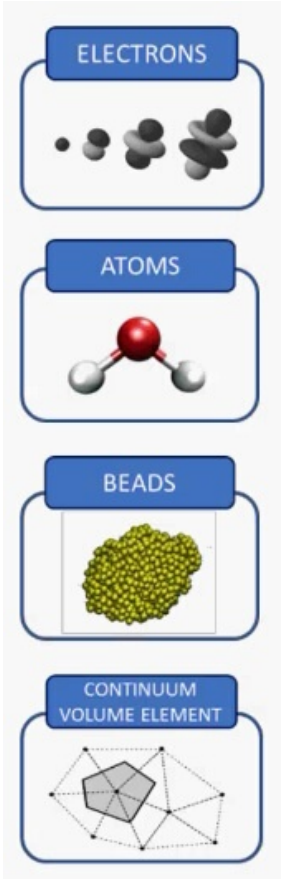
Elementary Multiperspective Material Ontology

EMMC

**Introduction and most recent release**
doi:10.5281/zenodo.3936795, **2021**

**Ontologies for the Virtual Materials Marketplace**
*KI – Künstliche Intelligenz* 34(3), 423–428,
doi:10.1007/s13218-020-00648-9, **2020**

# EMMO: Foundational ontology for EMMC/NMBP projects




*electronic*

*atomistic*

*mesoscopic*

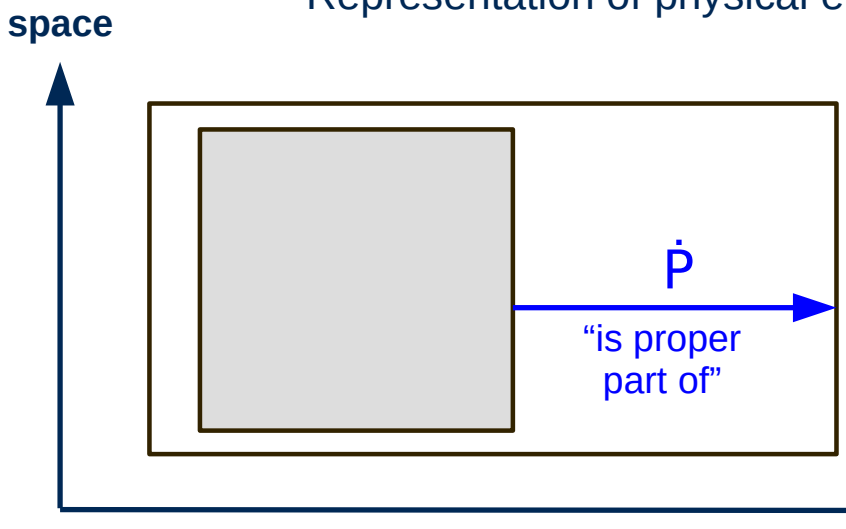
*continuum*

**Elementary Multiperspective Material Ontology**

1) **Taxonomy:**
   Conceptual hierarchy (subclass relation)

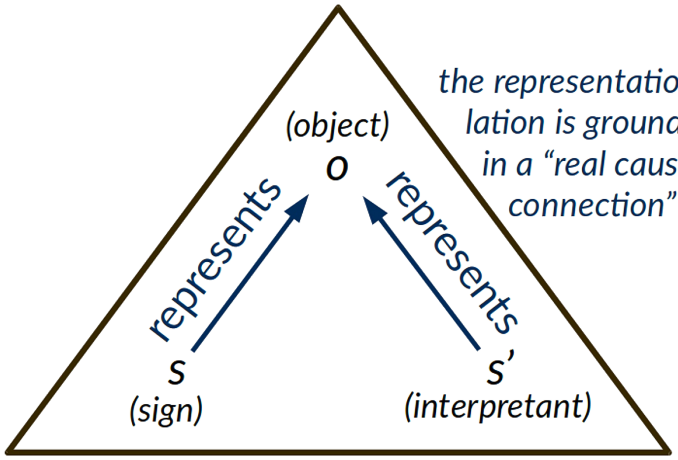
2) **Mereotopology:**
   Spatiotemporal parthood and connectivity

3) **Semiotics:**
   Representation of physical entities by signs




# EMMO: Foundational ontology for EMMC/NMBP projects

## Peircean semiotics




*the semiosis, a process by which a new representamen, the interpretant, is created*


C. S. Peirce

## Elementary Multiperspective Material Ontology[1, 2]

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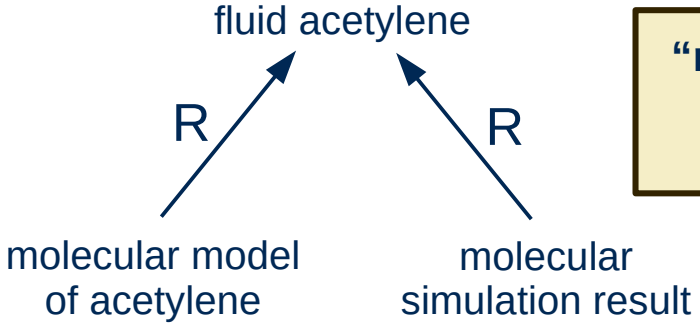
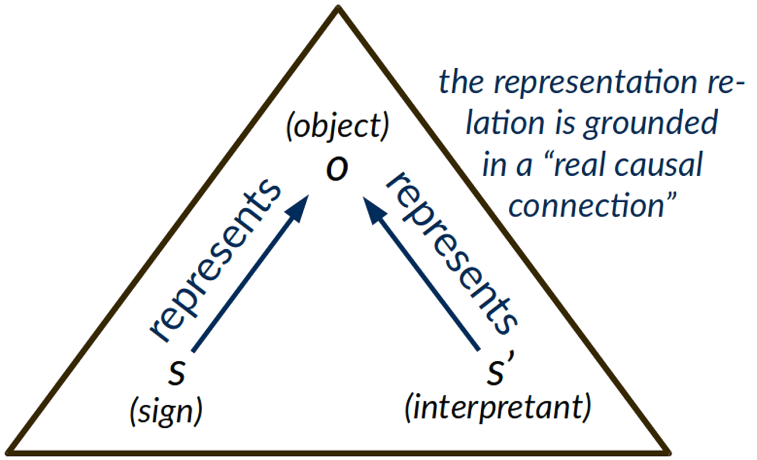



**"represents"** or **"is sign for"** is here abbreviated by **R**

[1]J. F. Morgado, E. Ghedini, G. Goldbeck, *et al.*, *Proc. SeDiT 2020*, **2020**.
[2]H. Preisig, T. Hagelien, J. Friis, *et al.*, *Proc. WCCM-ECCOMAS 2020*, **2021**.

# PIMS-II: Simulation workflows as cognitive processes

**Peircean semiotics**




*the semiosis, a process by which a new representamen, the interpretant, is created*

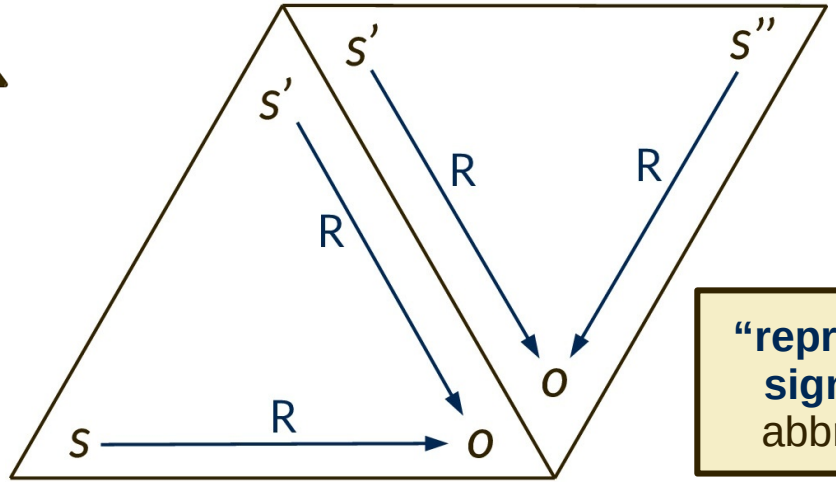
PIMS: „Physicalistic Interpretation of Modelling and Simulation“

PIMS-II stands for „PIMS Interoperability Infrastructure“

**Cognitive process (example):**

- First, experimental data *s* for the material *o* are used to parameterize a model, obtaining model *s'*.
- Then, a simulation is done using model *s'*, yielding the simulation result *s''* (which also represents *o*).

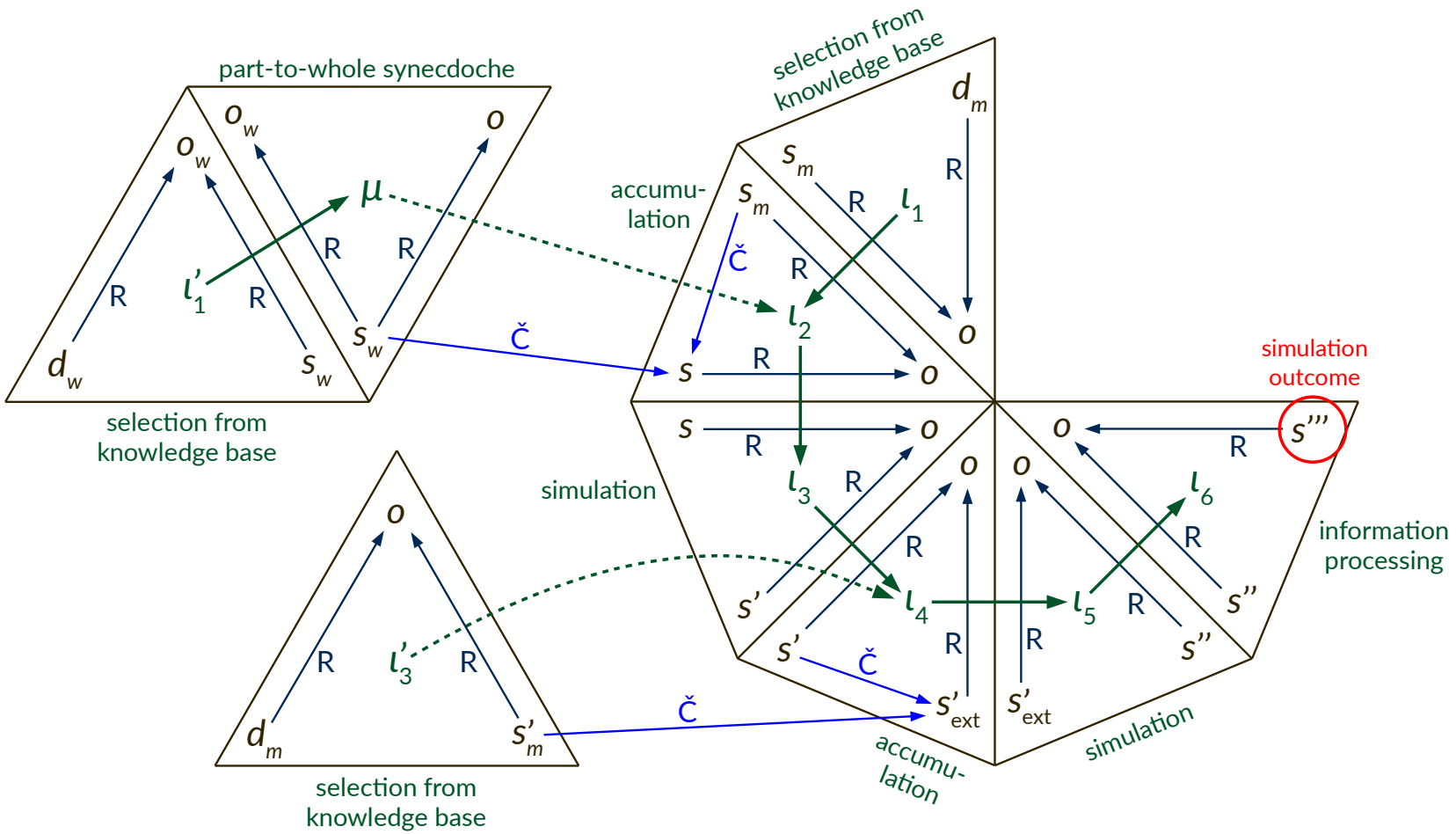
In Peircean semiotics, a representation relation is carried over from one cognitive step (*i.e.*, triad) to the next.[1]




**"represents"** or **"is sign for"** is here abbreviated by **R**

[1]Five scenarios suggested by Borgo and Kutz are annotated as examples at doi:10.5281/zenodo.4679522.

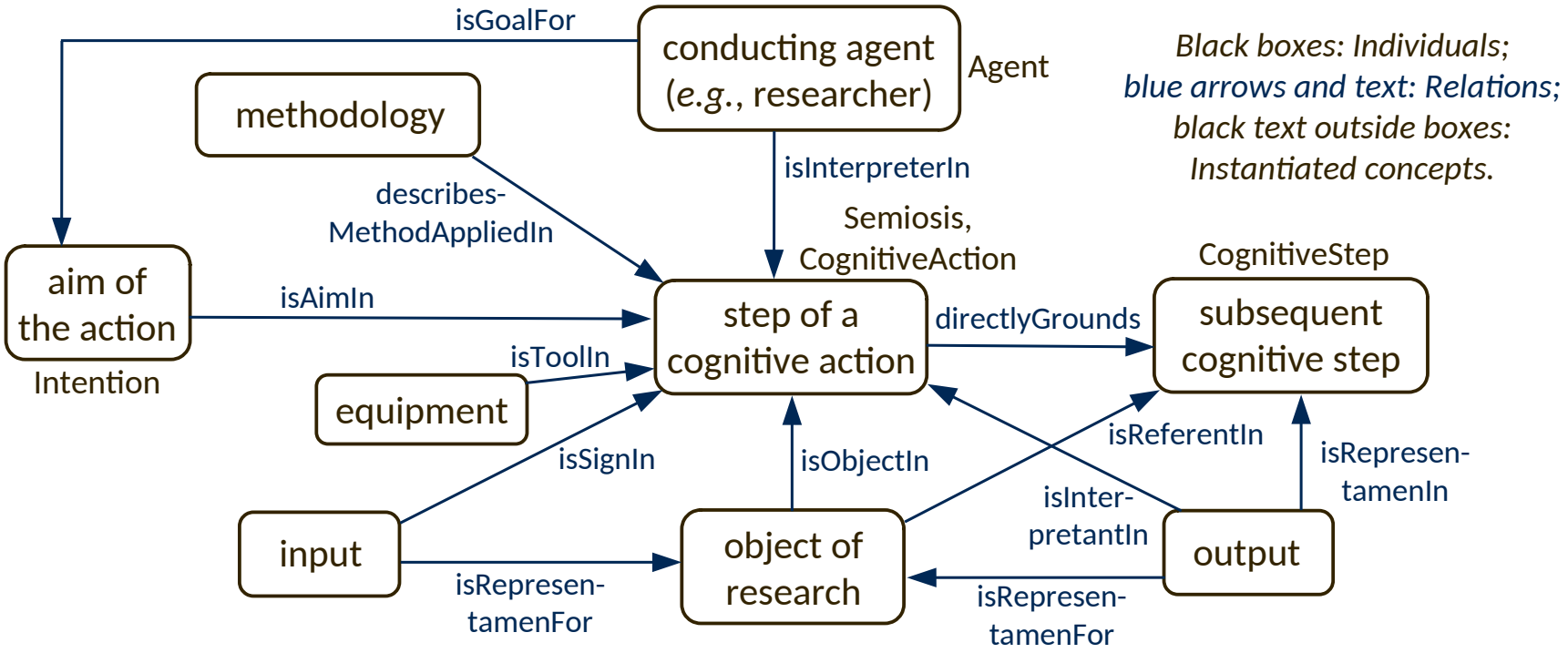
# PIMS-II: Simulation workflows as cognitive processes




P. Klein, H. A. Preisig, M. T. Horsch, N. Konchakova, *Proc. JOWO 2021* (FOMI 2021), **2021**.

# Schema for a cognitive action step

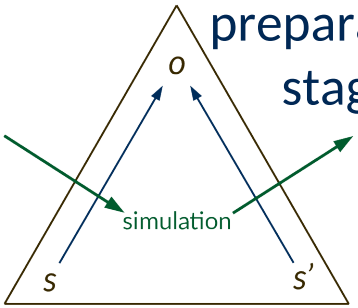
## PIMS interoperability infrastructure[1, 2, 3] (PIMS-II) knowledge graph template




[1]Relation to EMMO and MODA+OSMO discussed by P. Klein *et al.*, *Proc. JOWO 2021* (FOMI 2021), **2021**.
[2]PIMS-II OWL ontology for cognitive processes accessible at http://www.molmod.info/semantics/pims-ii.ttl.
[3]Modal first-order logic ontology at 10.5281/zenodo.4849611; examples at doi:10.5281/zenodo.4679522.

# Epistemic grounding and self-reflective behaviour

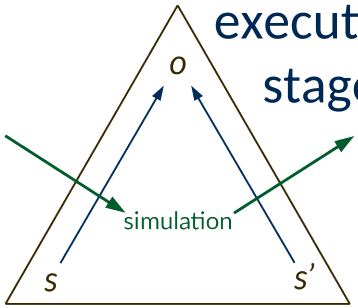
Three modes of providing justification by epistemic grounding, *i.e.*, by describing the process that yields a certain outcome that is to be grounded.




preparatory stage

*ex ante*

**Planning**

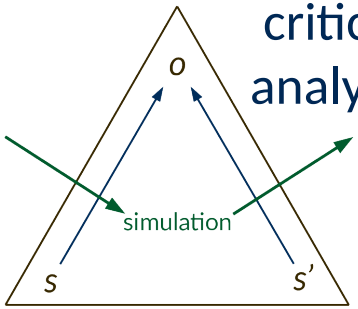



execution stage

*in actu*

**Steering**

*„Reflexion im Vollzug“*[1]




critical analysis

*ex post*

**Evaluation**

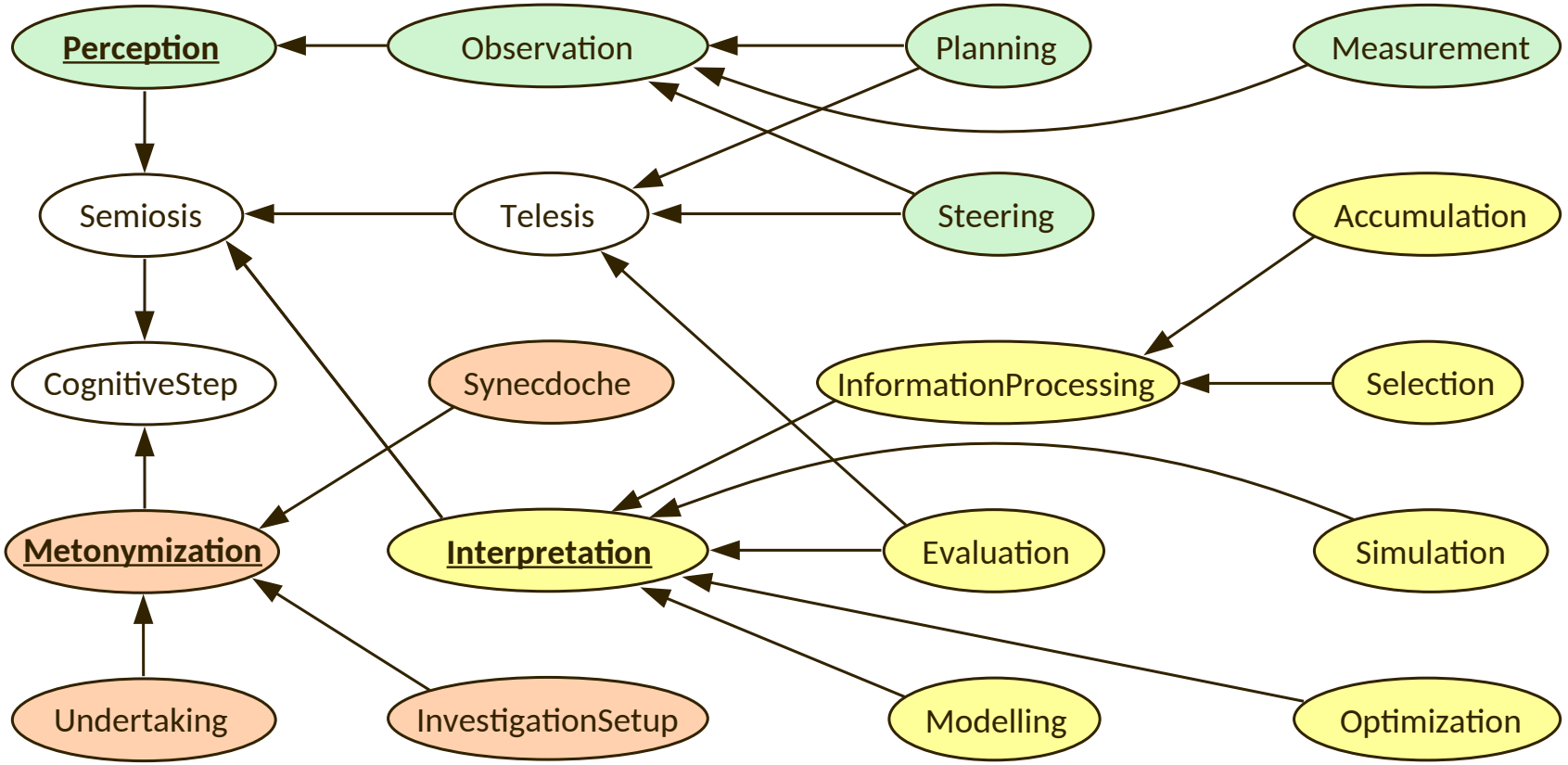
*„Reflexion des Vollzugs“*[1]

**Epistemic opacity** is reduced by **epistemic FAIRness**, *i.e.*, the FAIR provision of a provenance description via a research data infrastructure that permits a reevaluation of the research workflow over an open epistemic space.

[1]Tulatz, *Epistemologie als Reflexion wissenschaftlicher Praxen*, **2018**.

# Taxnonomy of cognitive steps

**Perception requires participation (overlap $\dot{P}$-$\dot{P}$) of the perceived object**

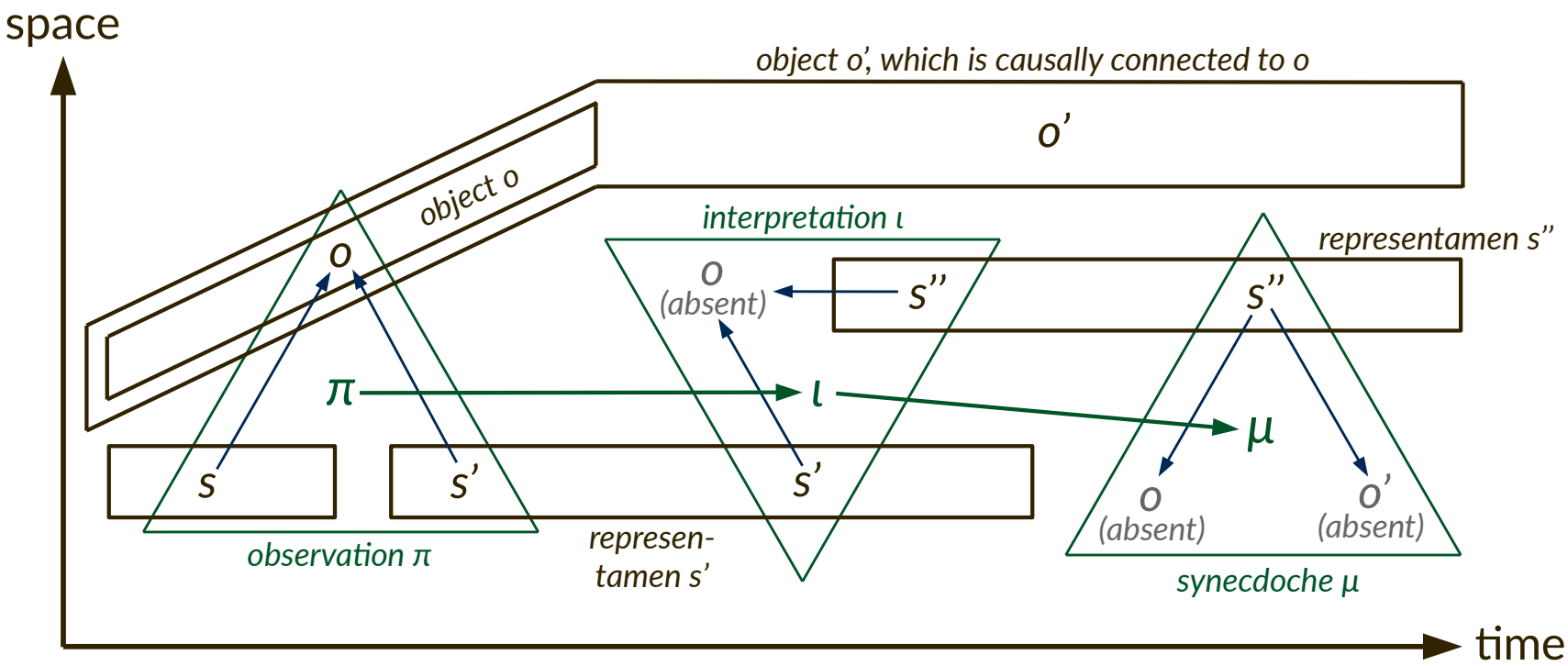



**Metonymization needs to preserve the „real causal connection“ (Peirce) between the old and new referents and representamen**

**Interpretation (and, similarly, metonymization) does not entail physical participation of referents in the respective cognitive step**

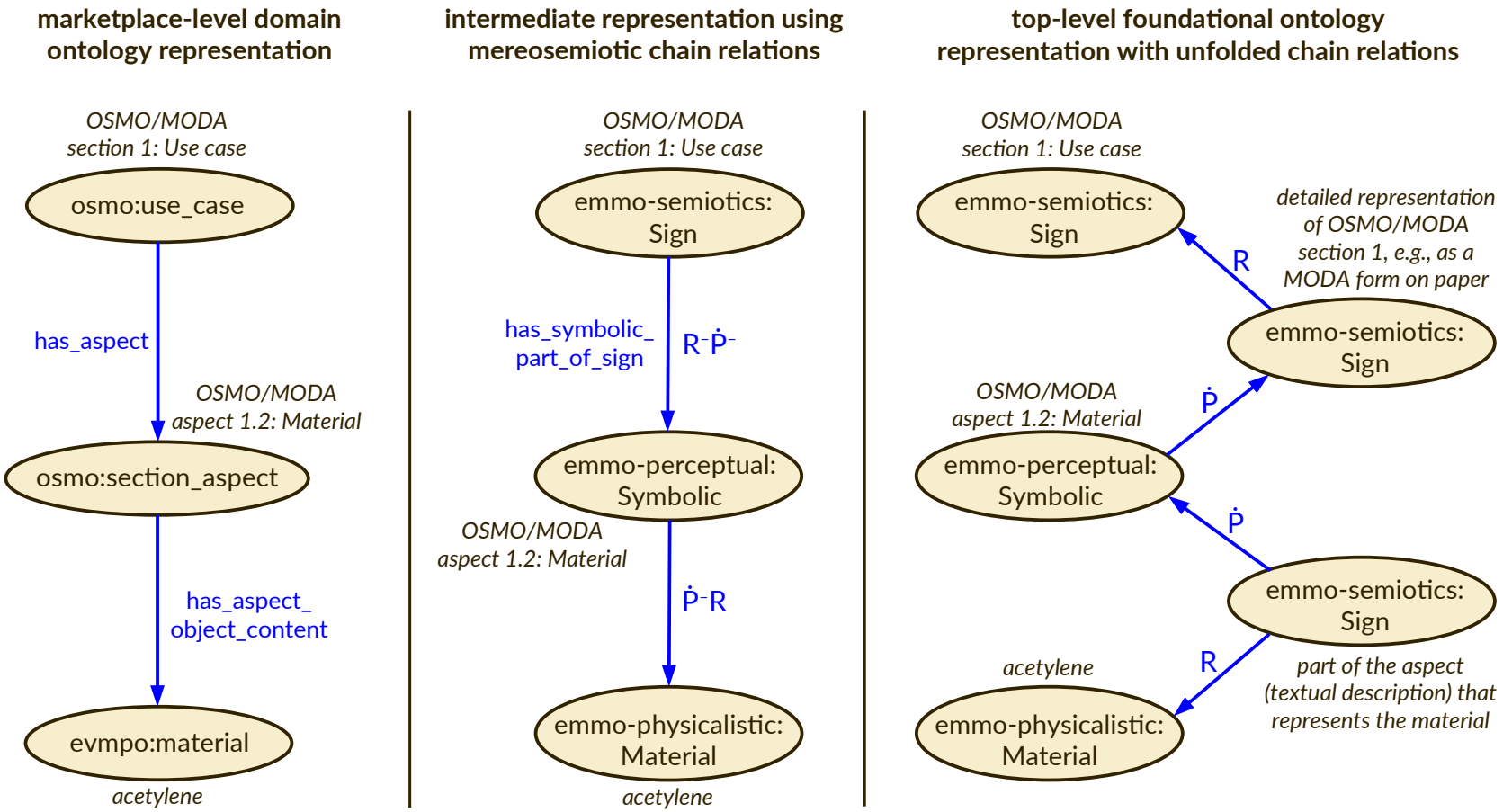
# Mid-level ontology for workflows as cognitive processes

**Mereosemiotics:[1, 2, 3] Combination of mereotopology and Peircean semiotics**



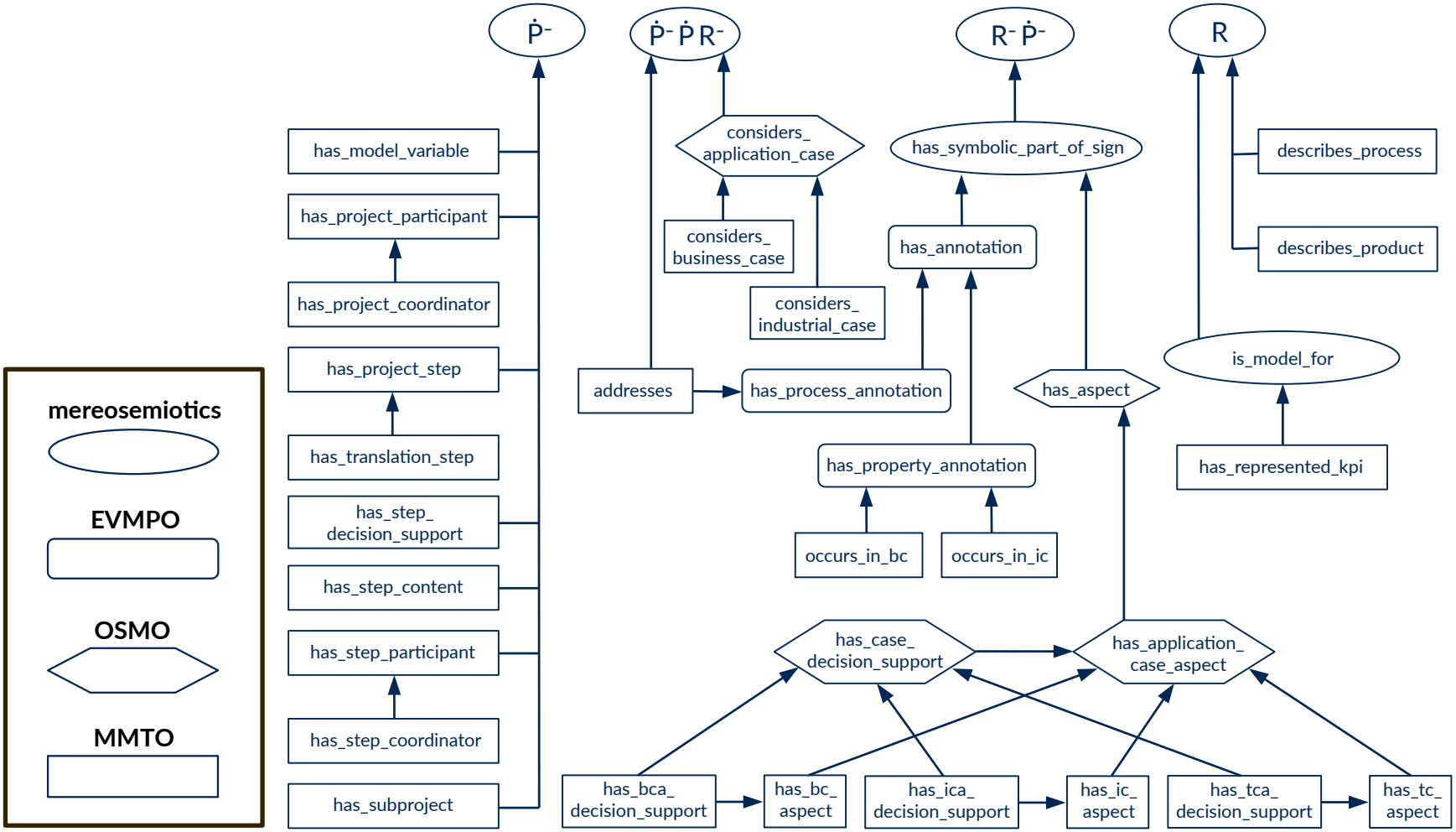

[1]M. T. Horsch, S. Chiacchiera, B. Schembera, M. A. Seaton, I. T. Todorov, *Proc. WCCM-ECCOMAS 2020*, **2021**.
[2]P. Klein, H. A. Preisig, M. T. Horsch, N. Konchakova, *Proc. JOWO 2021* (FOMI 2021), **2021**.
[3]First-order logic implementation, doi:10.5281/zenodo.4849611; examples, doi:10.5281/zenodo.4679522.

# Mereosemiotic chain relations: Ontology alignment



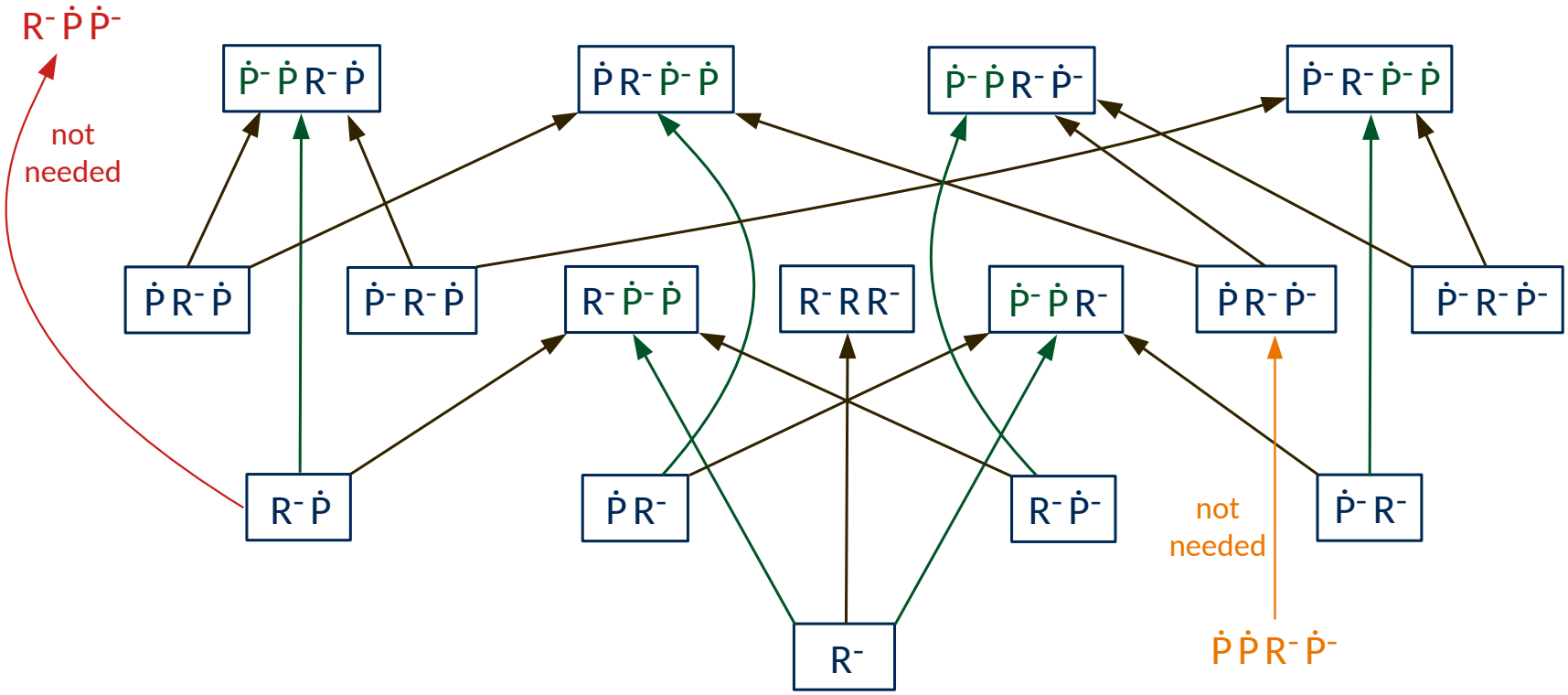

[1]M. Horsch, S. Chiacchiera, W. Cavalcanti, B. Schembera, *Data Technology in Materials Modelling*, Springer, **2021**.

# Mereosemiotic chain relations: Ontology alignment



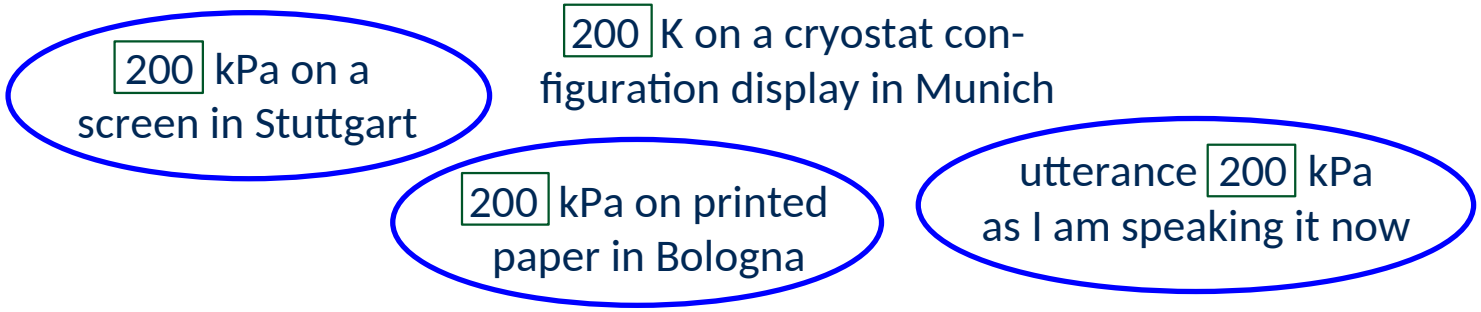
# Mereosemiotic chain relations: Subsumption hierarchy

PIMS-II employs a mereotopology such that overlap is $\dot{P}^{-}\dot{P} \equiv P^{-}P \sqsupseteq Id$ where $\dot{P}\dot{P}^{-} \equiv \top$ is the complete relation; proper parthood $\dot{P} \equiv \dot{P}^{n}$ ($n \geq 1$) is idempotent.



# Variables, quantity values, and semiotic collectives

„200 kPa“ is **one well-defined value**, it needs to be capable of **acting as such** (not just as one instance) as a representational element. The EMMO is based on nominalism and a mereotopology that distinguishes different 4D objects.




Another example: „The stadiums of the Premier League have a total capacity of 833 000 people.“ The referent of the property are all the stadiums together, as a collective; none of the individual stadiums holds 833 000 people.

The EMMO defines items (contiguous 4D regions) and mereotopological collectives („Collections“); however, the latter concept needs to be generalized.[1]

[1]M. Horsch, S. Chiacchiera, B. Schembera, M. Seaton, I. Todorov, *Proc. WCCM-ECCOMAS 2020*, **2021**.

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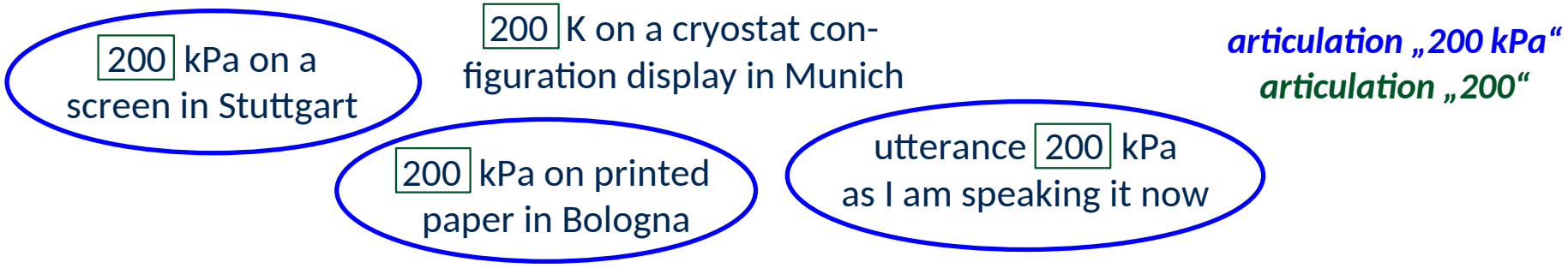


Previous work by Masolo *et al.*[1] proposes three kinds of collectives: Pluralities, (proper) collectives, and composites. The PIMS interoperability infrastructure[2] mid-level ontology defines **semiotic collectives** as entities that appear jointly as a representational element, *i.e.*, as representamen or referent. Four kinds of semiotic collectives are: Pluralities, structures, articulations, and propositions.[2]

[1]C. Masolo, L. Vieu, R. Ferrario, S. Borgo, D. Porrello, *Proc. FOIS 2020*, pp. 186–200, **2020**.
[2]M. T. Horsch, *Proc. JOWO 2021* (FOUST 2021), preprint doi:10.5281/zenodo.4849611, **2021**.

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