Domain-specific ontology for digital continuity: Thermal Engineering case

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European Space Agency (ESA)

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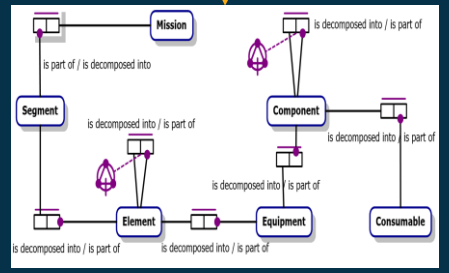
Domain-specific ontology for digital continuity: Thermal Engineering case

Objective:

Initial definition of the thermal process model

Identification of the Object-Fact types of the ORM ontology



Object-Role Modelling (ORM)
Semantic modelling /ontology

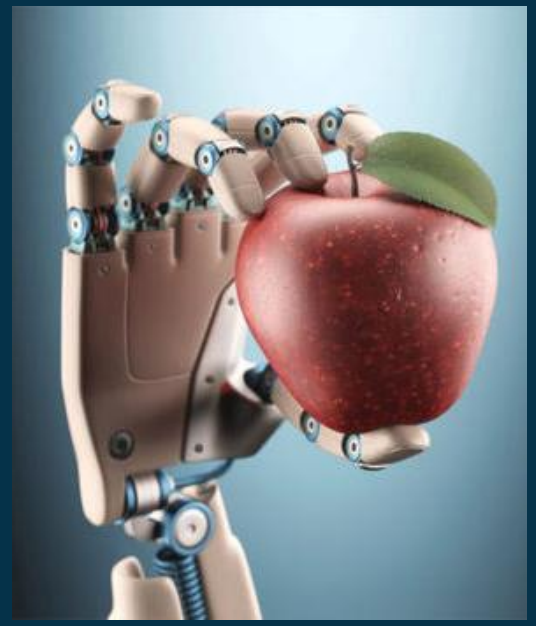
MBSE4THERMAL

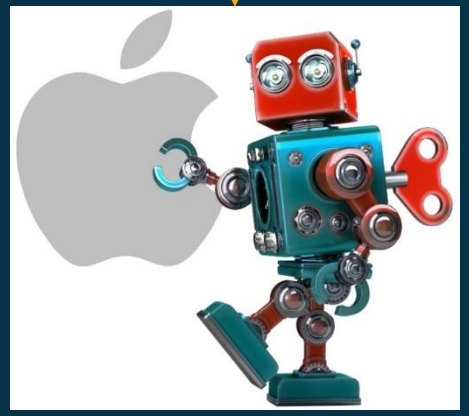
- Design knowledge
- Estimation of design performance
- Optimize review process

Introduction: Semantic modelling (ontology)

"Formal, explicit specification of a shared conceptualization"

APPLE



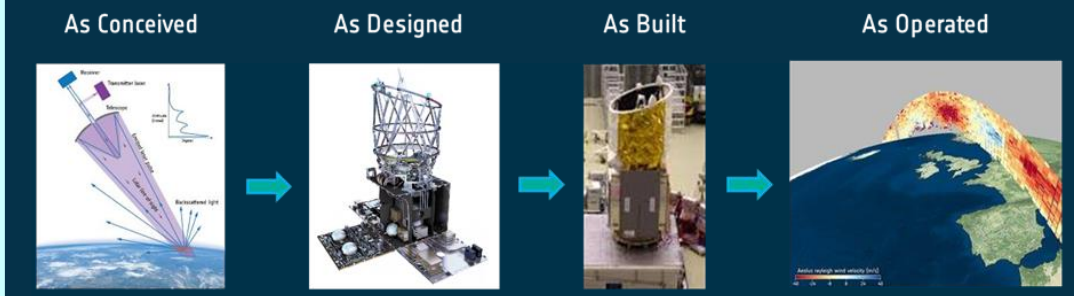


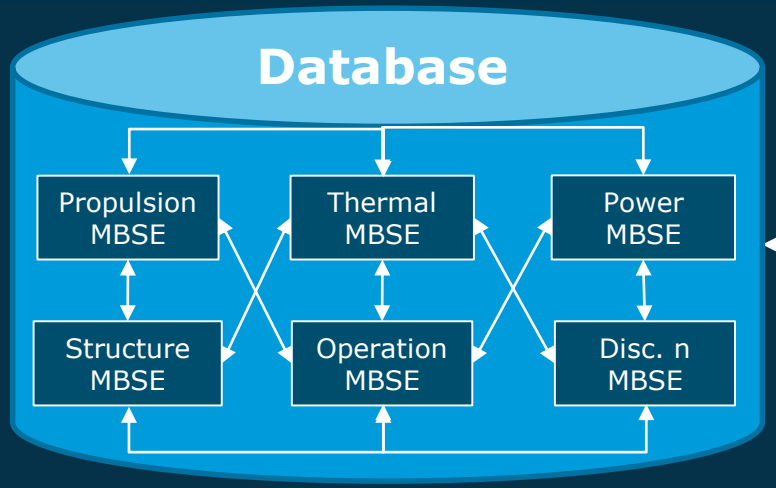
- Ontology-Based Systems Engineering (OBSE):
  - Explicit the nature and the structure of engineered systems.
  - Helps domain engineers to understand the system complexities and its socio-technical environments.

Introduction: What is the problem?

ESA Agenda 2025: ESA will 'digitalise its full project management, enabling the development of digital twins, both for engineering by using Model Based System Engineering, and for procurement and finance, achieving full digital continuity with industry.'

Digital Spacecraft





Digital Continuity (MBSE in disciplines and projects)

Standardization

The European Cooperation for Space Standardization (ECSS): a coherent, single set of user-friendly standards for use in all European space activities.

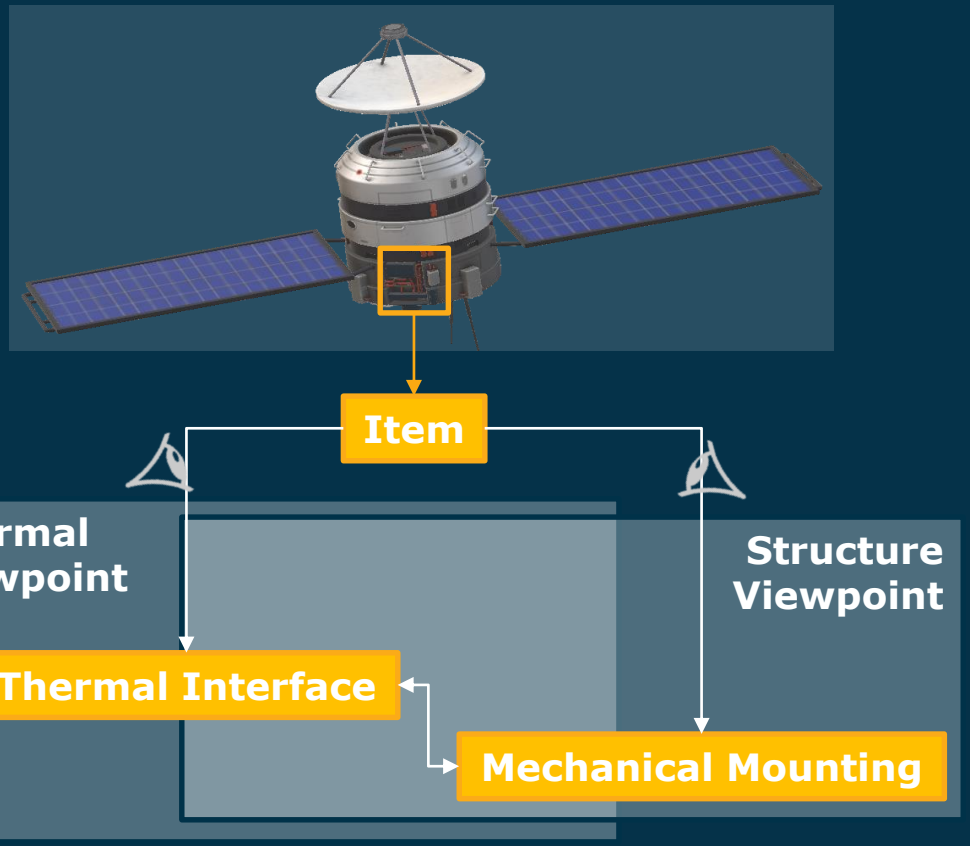
Interoperability

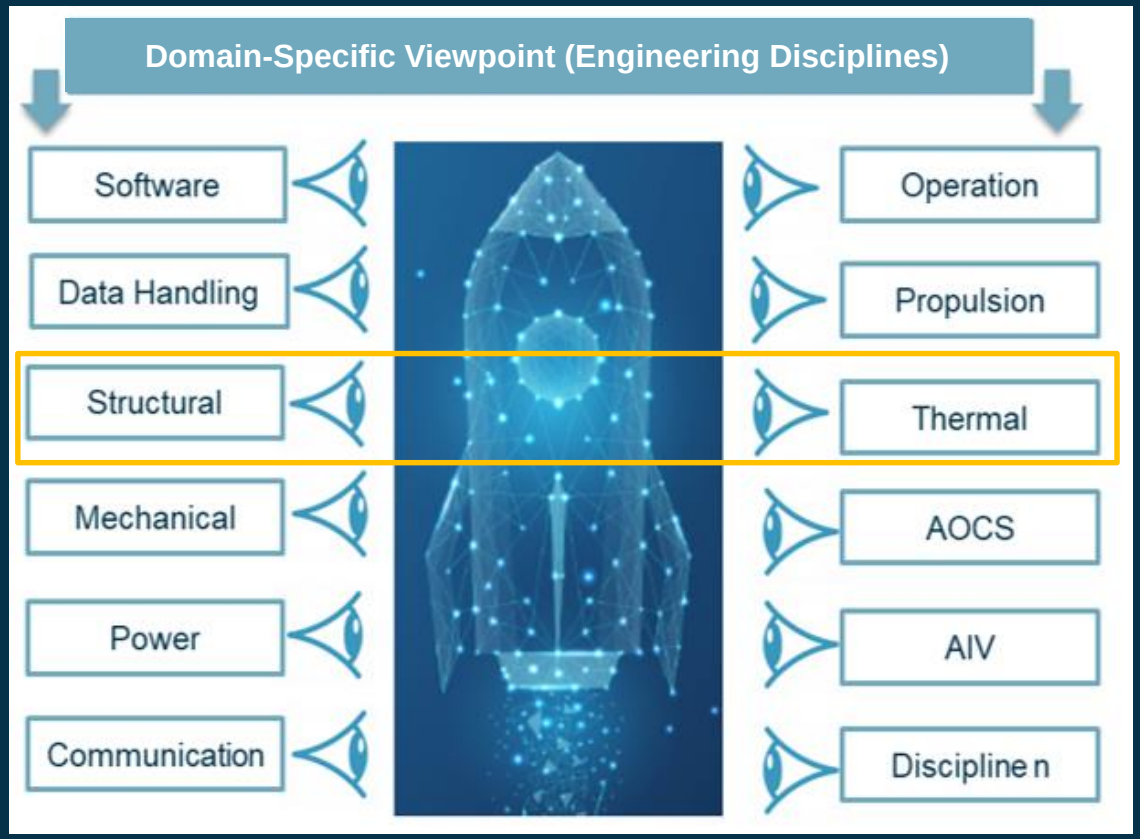
OSMoSE (Overall Semantic Modelling for System Engineering)

- A top-level ontology called Space System Ontology (SSO)
- Various modular domain ontologies, Universe of Discourse (UoD), integrated into the ESA top-level SSO.

Introduction: What is the problem?

- Each UoD focuses on one discipline's semantics ➡ Interoperability issues
- Requirements towards other discipline ➡ interfaces and data exchange between disciplines

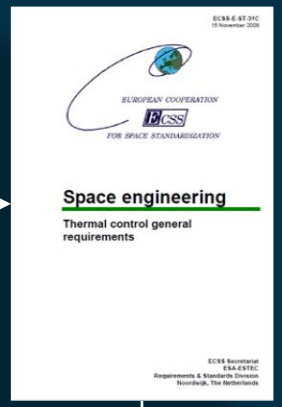




Introduction: The need for Thermal Ontology

Standardizati

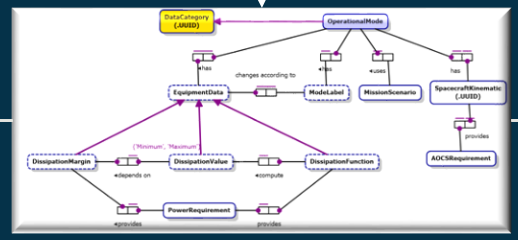
Defined in
ECSS-E-ST-31C15



Interoperabili

Input to the
OSMoSE SSO

Domain Expert Knowledge



- Considering Requirements towards other disciplines
- Mapping to system concepts

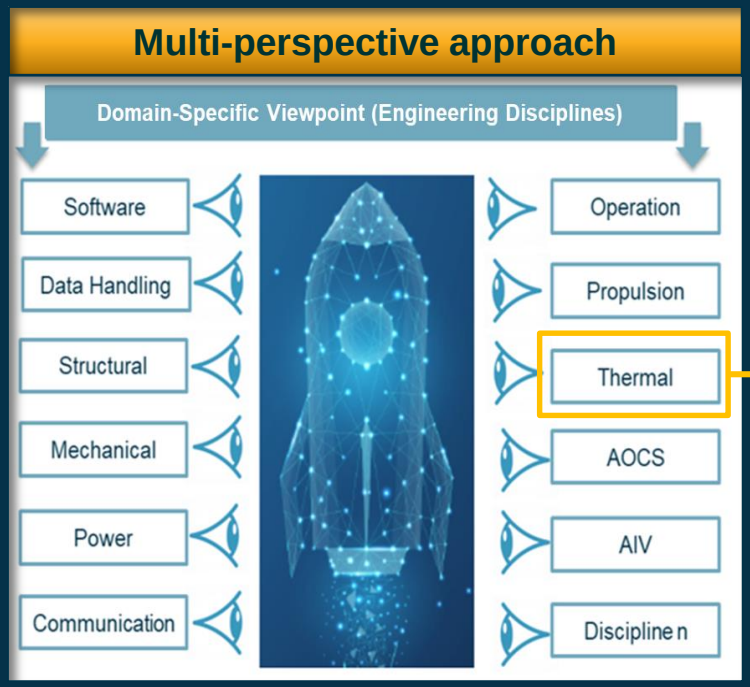
Digital Continuity

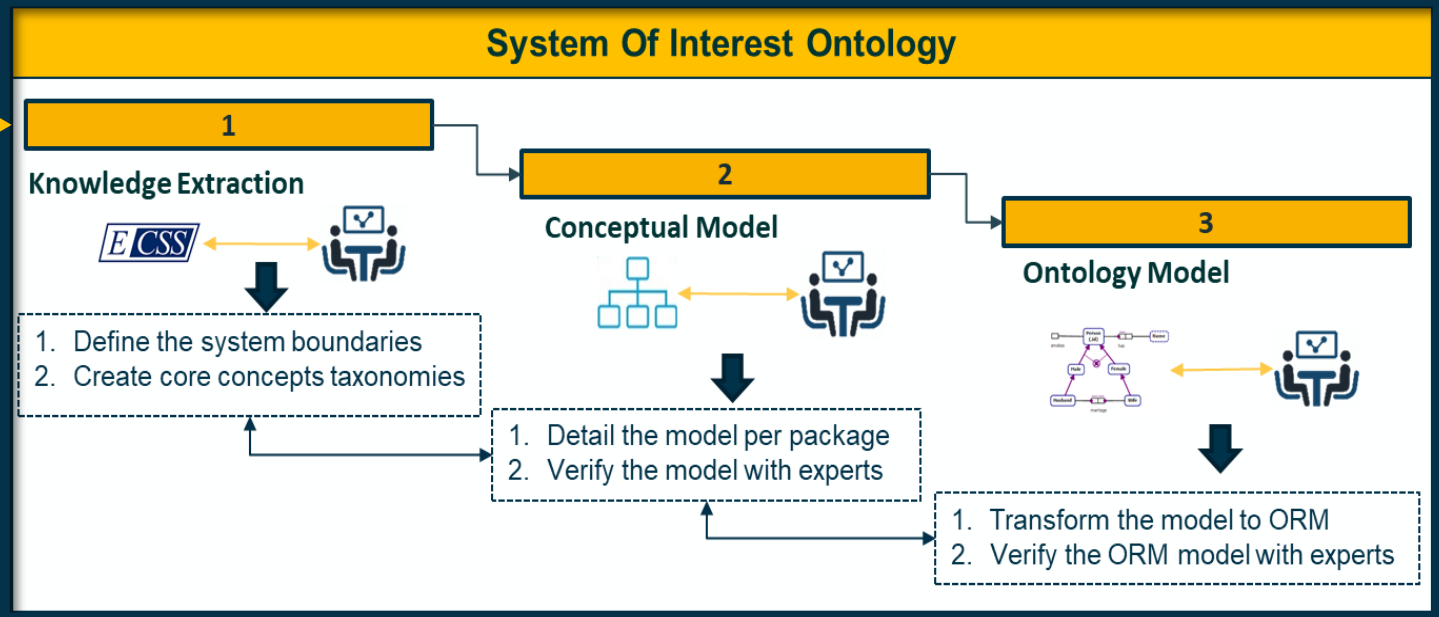
Input to the
MBSE4Thermal

- Design knowledge
- Estimation of design performance
- Optimize review process

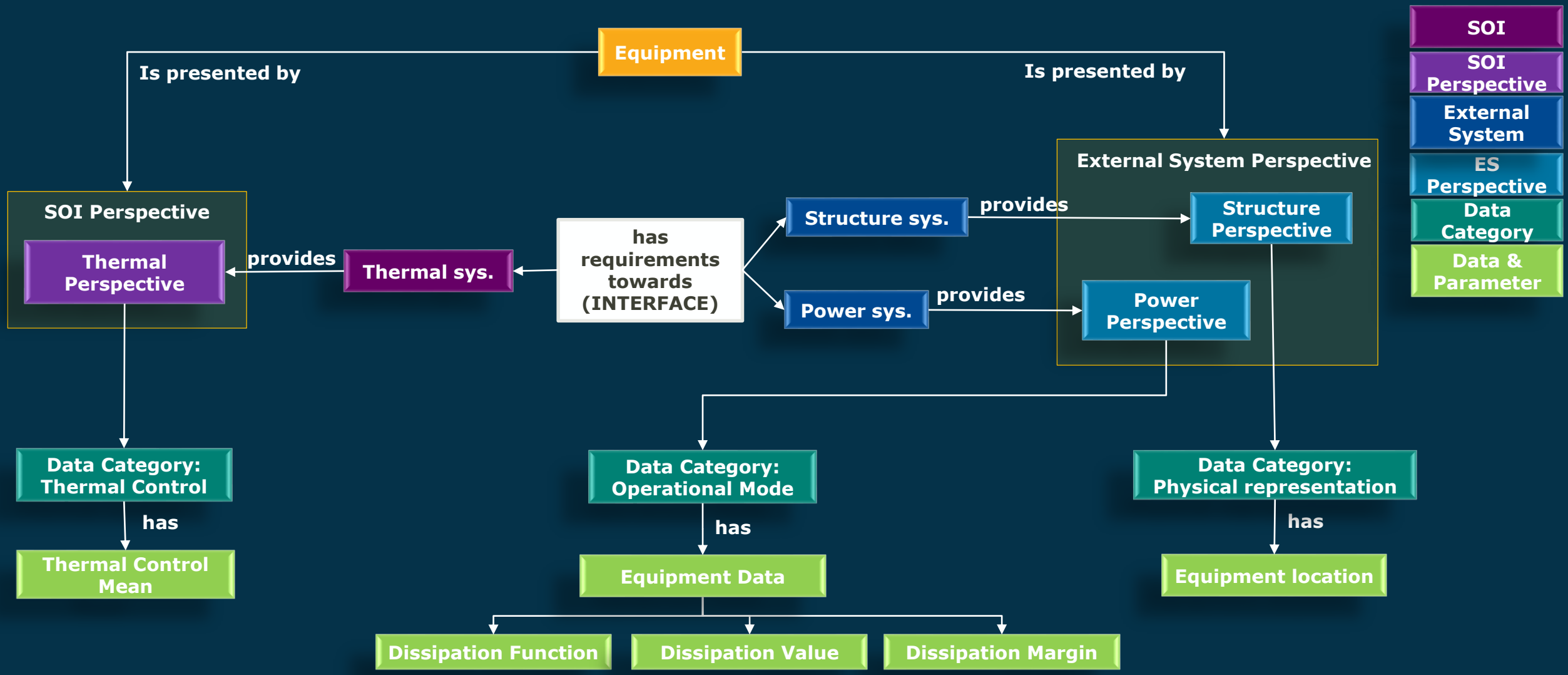
Research: What has been done

- Multi-viewpoint approach (presenting various aspects of a sub-system)
- Domain-specific ontologies (domain experts' knowledge + space domain references)
- Modular ontology





Research: Semantics specified in Thermal domain



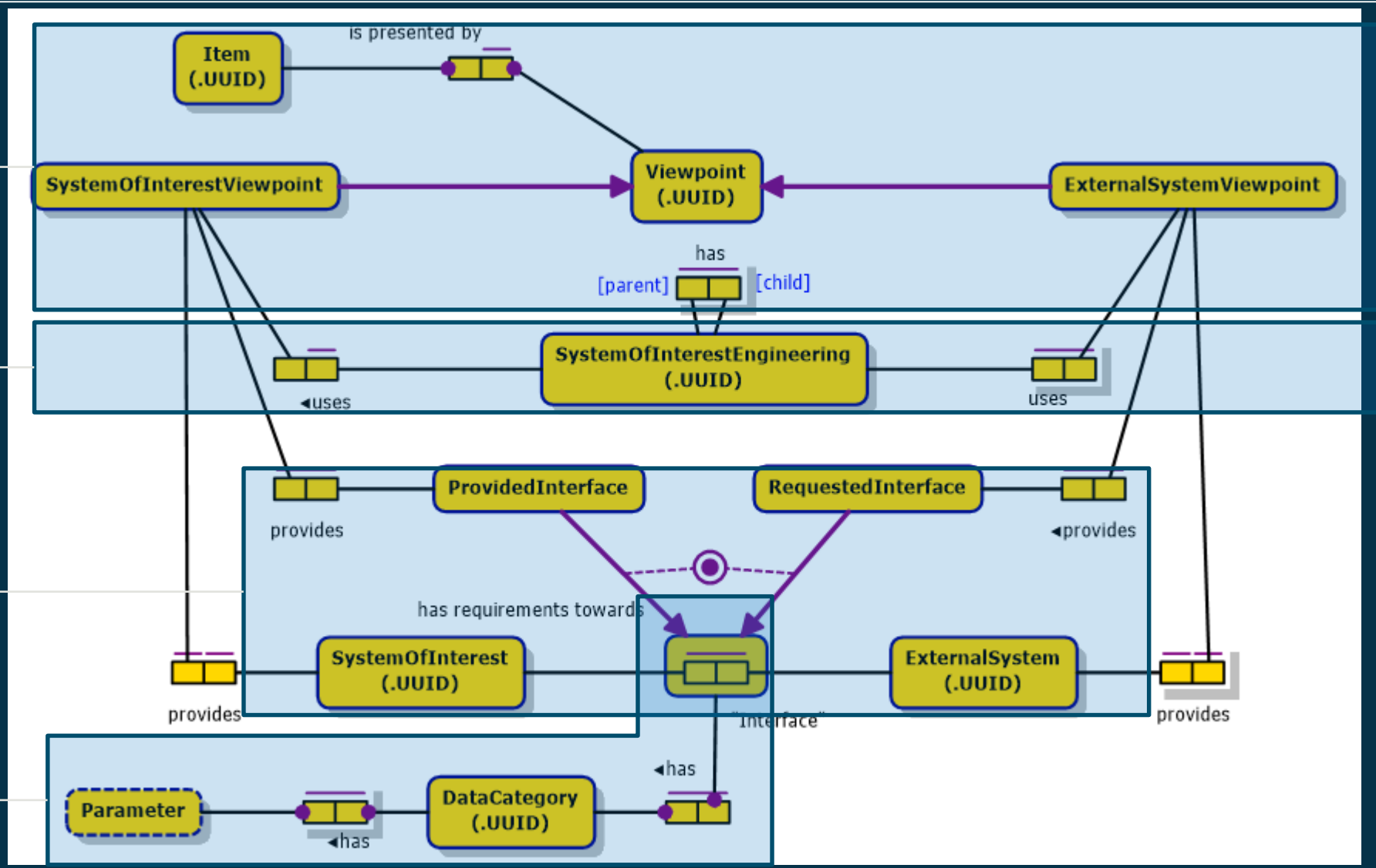
Research: Viewpoints in Thermal ontology

Item is presented by Viewpoints

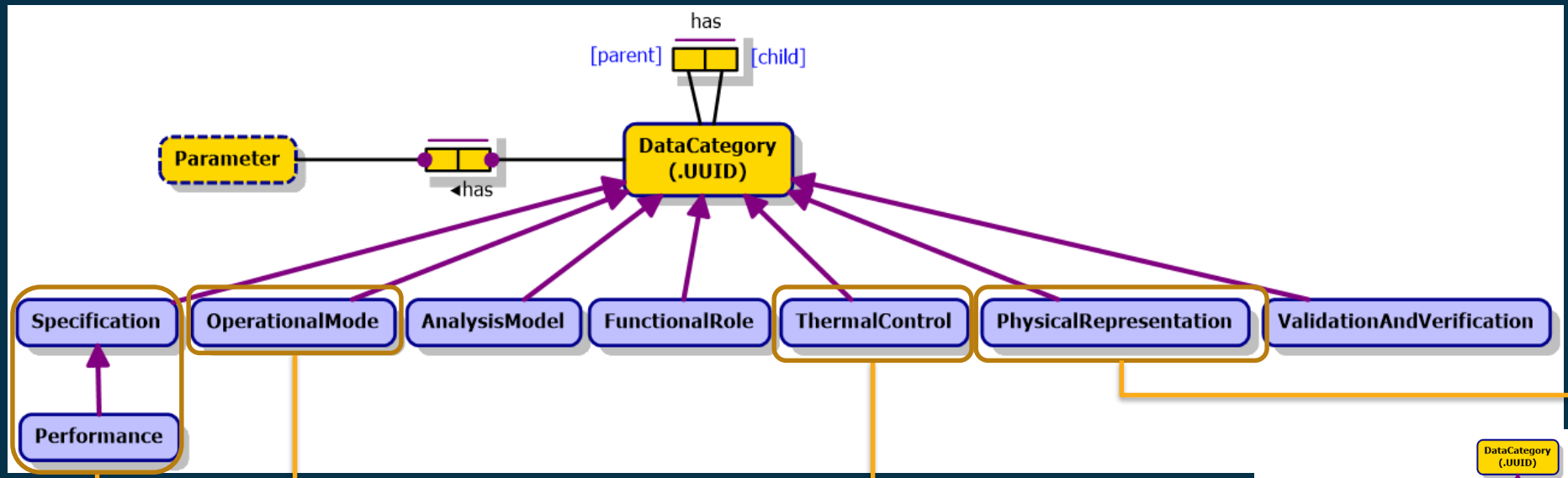
SOI engineering uses Viewpoints

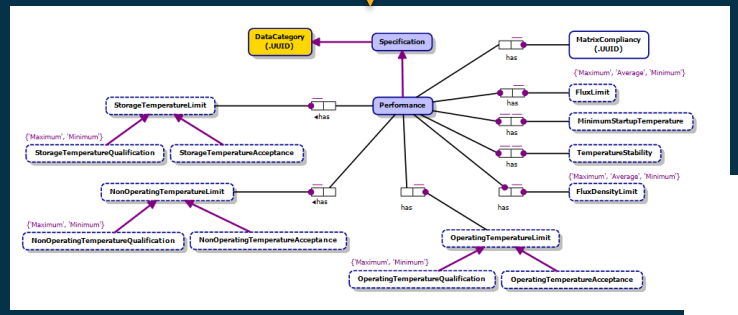
Interfaces between SOI and ES

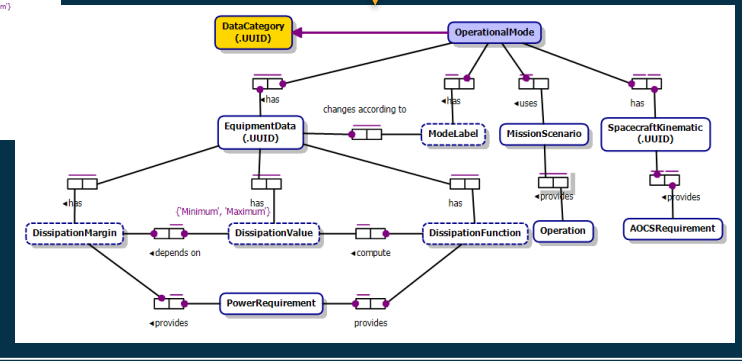
Interfaces has Data Category

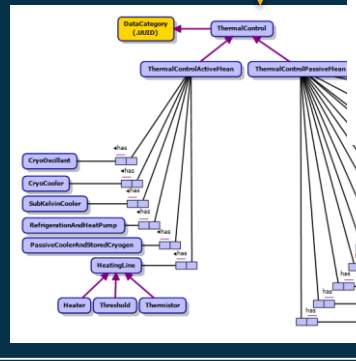


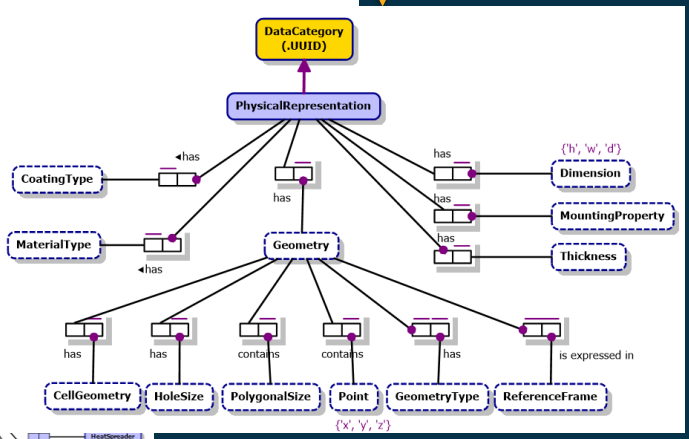
Detailed ontologies





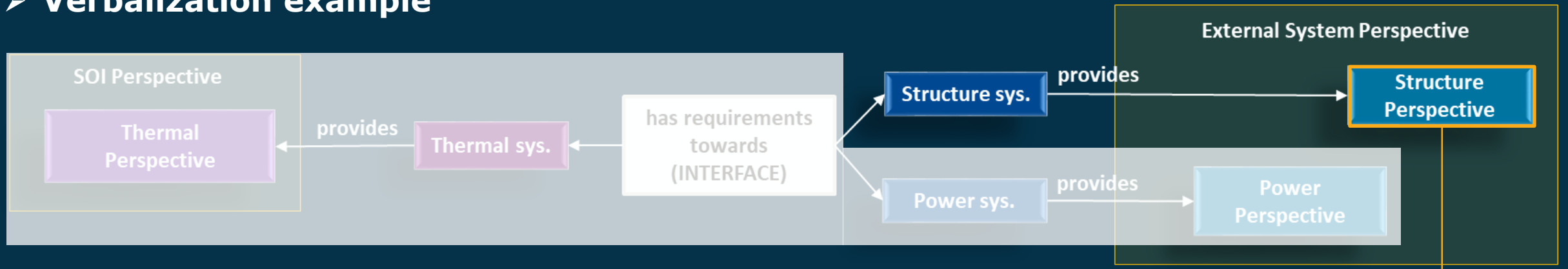






Research: Viewpoints in Thermal ontology

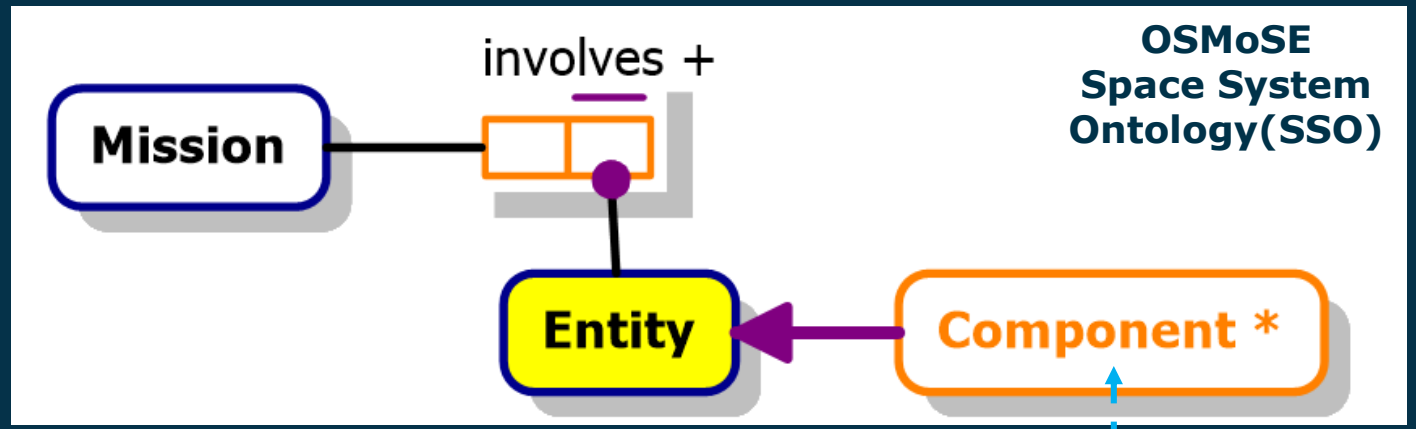
➢ Verbalization example



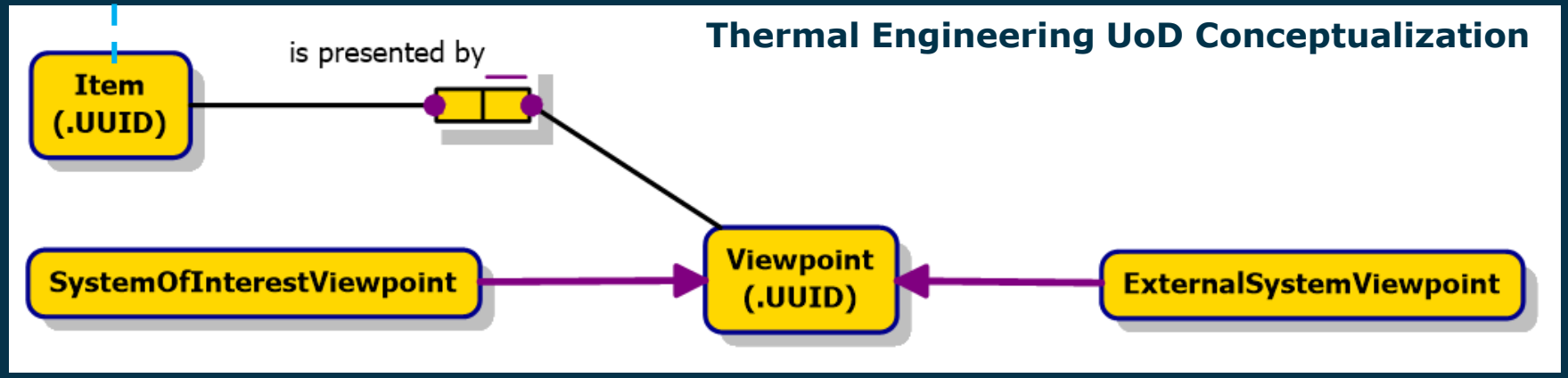
StructureRequirement **is an entity type**.
***Each** StructureRequirement **is by definition some** ExternalSystemViewpoint **where that** ExternalSystemViewpoint **exists**
where some Equipment **exists**.
Reference Scheme: Viewpoint has Viewpoint_UUID.
Reference Mode: .UUID.
Data Type: Numeric: Signed Integer.

Fact Types:
StructureSystem provides StructureRequirement.
Each StructureRequirement is an instance of ExternalSystemViewpoint.
StructureRequirement has PhysicalRepresentation.

Research: Mapping Thermal ontology to OSMoSE

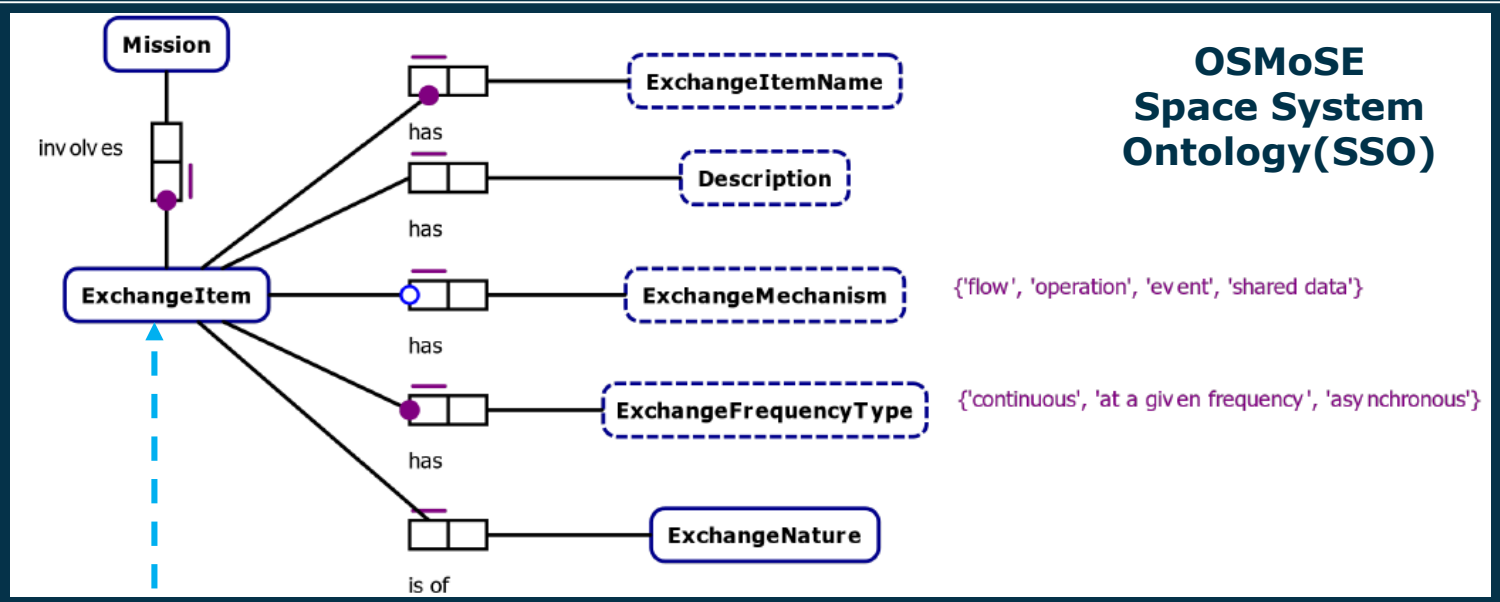


Thermal Engineering UoD Conceptualization is a contribution to the SSO to be submitted for review by SSO Design Authority.

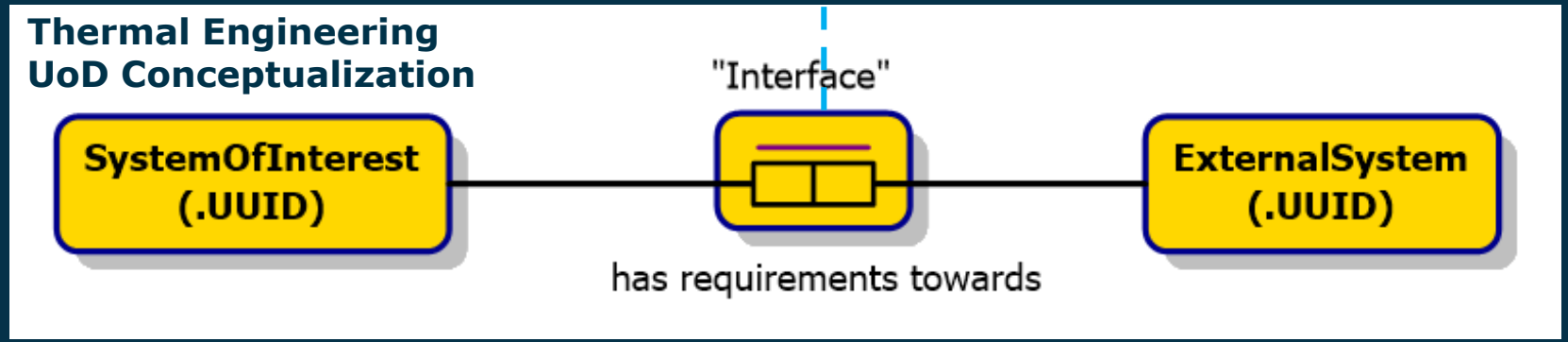


Research: Mapping Thermal ontology to OSMoSE

Thermal Engineering UoD Conceptualization is a contribution to the SSO to be submitted for review by SSO Design Authority.



Map to



Conclusion

- **Lessons Learned:**
  - ECSS ontology cannot be created without the experts' knowledge integration.
  - Eventually, Thermal ECSS standards might be completed to align them with daily usage.

- **Open points for future work**
  - Adding ECSS-E-ST-31 semantics into the current Thermal ontology
  - Including additional detailed features from the engineering process semantics
  - Utilisation for a concrete example (e.g. design performance estimation on spacecraft panel)
  - The integration of the Thermal concepts into the SSO
  - Extending the domain ontologies to cover different engineering domains
  - Full implementation and testing of this proposal for all space disciplines

Thank you for your attention!

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