

FORMAL DESCRIPTION FOR AUTOMATIONML

Mapping AutomationML to Ontologies

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GmbH



Why this working group?

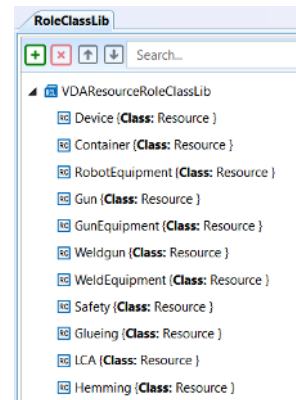


Table 3 – RoleClass DataSheet

Class name	DataSource
Description	The role class "DataSource" is an abstract role concept and the base class for all DataSource. It shall directly or indirectly reference this role.
Parent class	RoleClassLib/LogicalDevice



Table 2 – Interface ExternalDataReference

Description	The interface class "ExternalDataReference" is used to reference external documents out of the AutomationML structure.
Parent class	AutomationMLInterfaceClass
Path for element reference	AutomationMLBPRIInterfaceClass
Attributes	Name: MIMEType Name: refURI (by inheritance)

2.1.1 Site

Klassenname	Site
Beschreibung/Description	Abgestimmte VDA-Rollenklasse! Quelle IFC 42714-2 (IF4.1.0): The role class "Site" should be used for the position determination of a site. It is also used as element of a hierarchical organization. The definition of a "Site" is given in IFC 42764-1 (2013, 5.3.3): "A site is a physical, geographical, or logical grouping determined by the enterprise. It may contain areas, production lines, process cells, and production units." Beispiele sind Werke. Diese Rollenklasse ist verpflichtend zu verwenden.
Hierarchie	AutomationML/Interface/ClassLib/204
Kinderelemente	• ExternalDataReference • Area • Strukturgruppen (gem. 2.3)

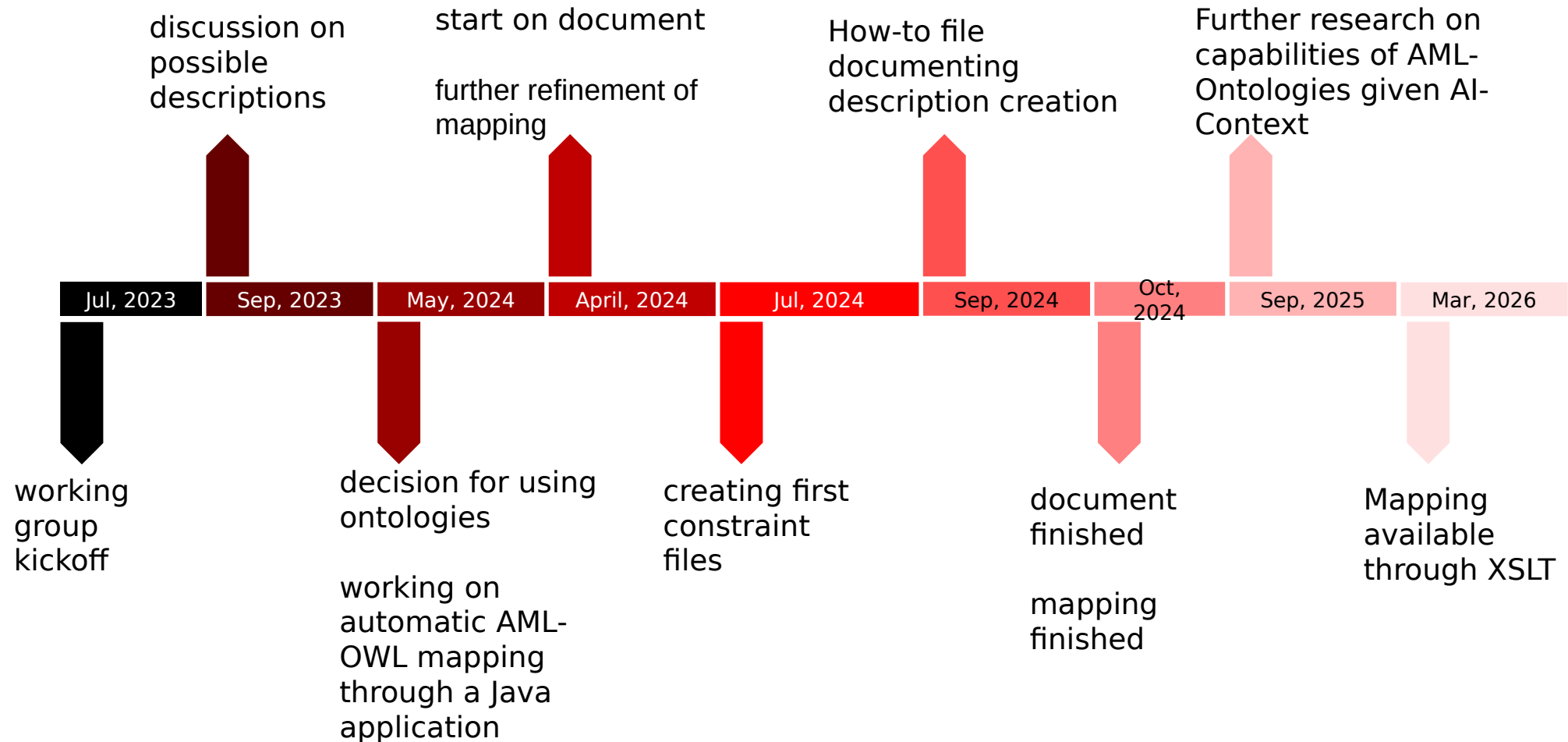


✓ Object classes
in AutomationML (XML)

⚡ restrictions
(no computer readability)

A neutral, formal description is missing

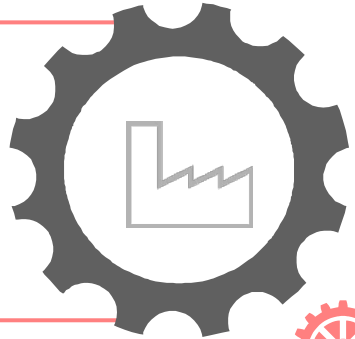
Roadmap: where are we?



Ontologies are descriptions of concepts

Definition

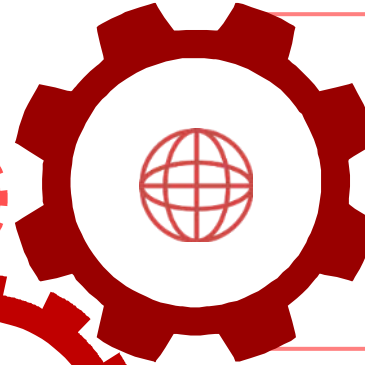
Description of domain knowledge through attributes and relationships



Easy communication

Easy machine readability

W3C defined RDF as standard for resource description



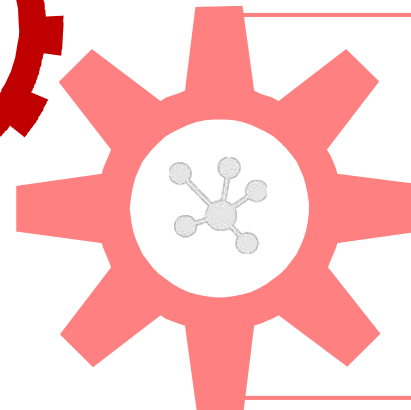
Realization of equivalence relations

To ease workflow and help discover new properties



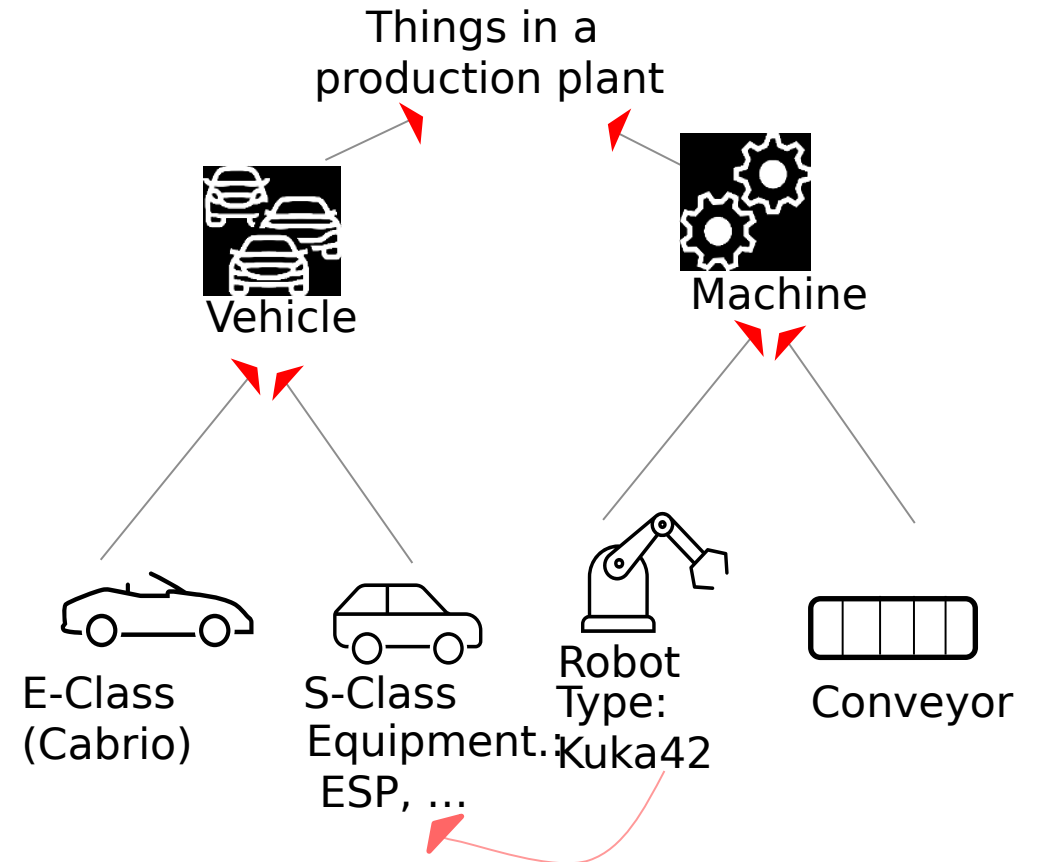
Easy visualization

different tools offer integrated libraries to visualize your ontologies



What is an ontology?

- Information stored as
 - Objects
 - Relations
 - Instances
- Machine-readable
- Machine-interpretable
- Contains Semantics
 - Even the meaning of information is machine-readable
 - „What does it mean to be a child?“



Ontologies built from AutomationML

- Internal Elements, Attributes, Interfaces mapped as Individual
- RoleClasses, InterfaceClasses, AttributeTypes mapped as Classes
- Inheritance mapped as Subclasses

▲ **IE** Werk { Role: Site }

▲ **IE** Gebaeude { Role: Area }

▲ **IE** Geschloss1 { Role: Area }

▷ **IE** Band1 { Role: ProductionLine }

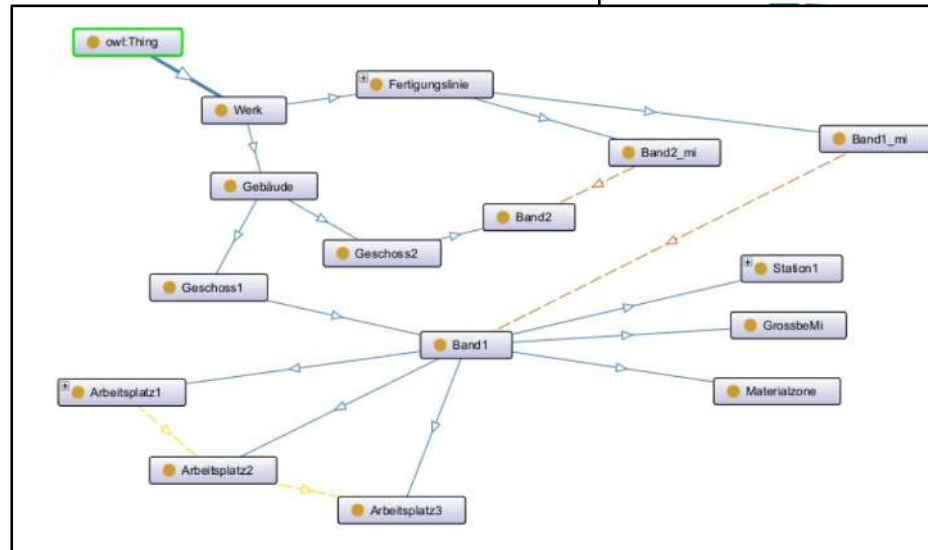
▲ **IE** Geschoss2 { Role: Area }

▷ **IE** Band2 { Role: ProductionLine }

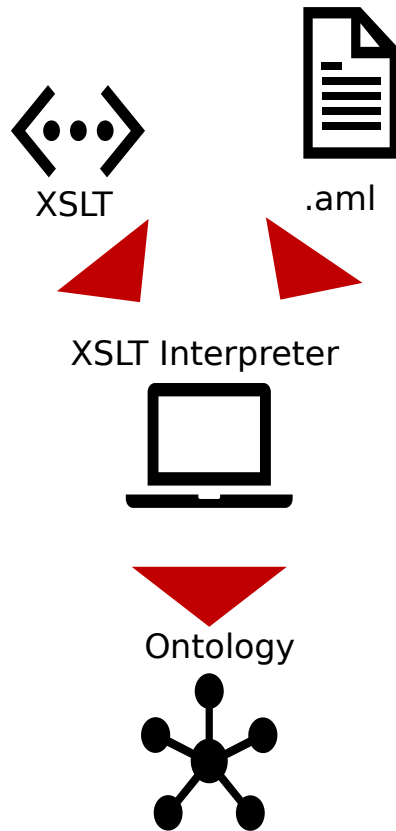
▲ **IE** Fertigungslinie { Role: ManufacturingArea }

Master: Band1}

Master: Band2}



What do you need to use the Ontology Mapping?



XSLT Schema
available at
AutomationML-Git



Apply schema
through suitable
editor to .aml file

The AI-Boom and its issues...

01

Too much data

Huge quantity of data without clear structure or meaning



02

Not enough context

Data without semantic connections



03

Hallucination

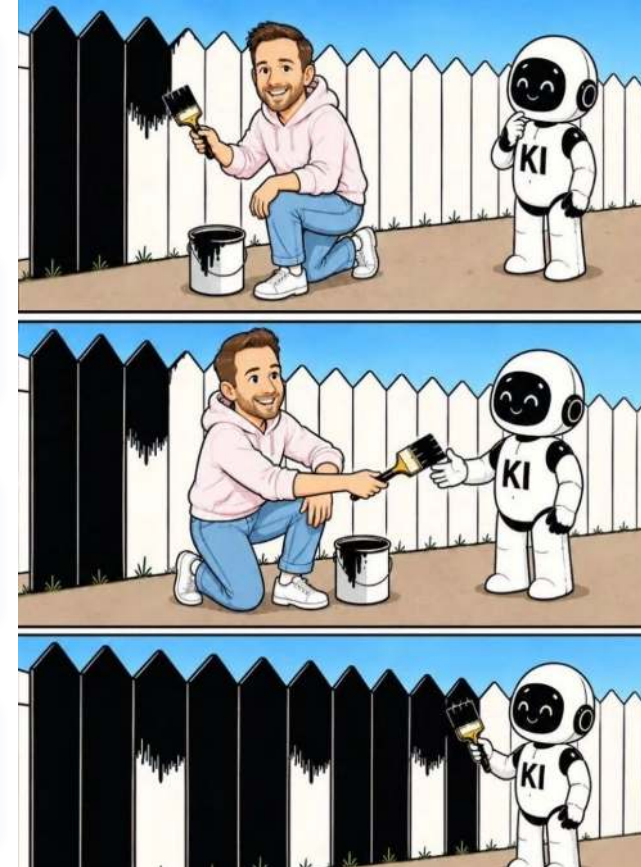
Since a reliable context is missing



04

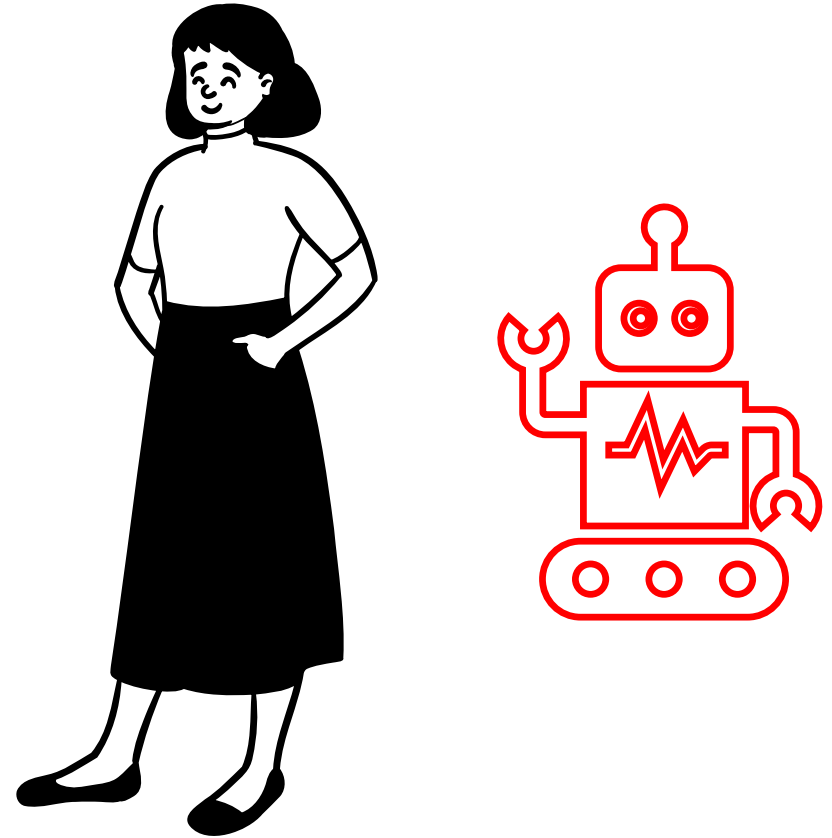
Trust issues

Users lose their trust in AI-tools

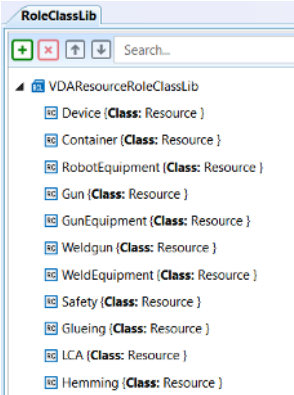


Benefits of AutomationML Ontologies

- AutomationML as source for AI
 - Much knowledge already documented
 - Knowledge in areas where regular AI models often struggle
 - Domain-specific knowledge
 - Special vocabulary
 - Use cases require high trustworthiness
- Problem: AutomationML is not easy to connect to AI
- Converter AML => Ontologies
 - Using the benefit of ontology-tooling and research
 - While making use of many years of AutomationML knowledge



Why this working group?



RoleClassLib

- VDAResourceRoleClassLib
 - Device (Class: Resource)
 - Container (Class: Resource)
 - RobotEquipment (Class: Resource)
 - Gun (Class: Resource)
 - GunEquipment (Class: Resource)
 - Weldgun (Class: Resource)
 - WeldEquipment (Class: Resource)
 - Safety (Class: Resource)
 - Glueing (Class: Resource)
 - LCA (Class: Resource)
 - Hemming (Class: Resource)

Table 3 – RoleClass DataSource

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Table 2.1.1 Site

Klassennamen	Site
Beschreibung/Description	Abgestimmte VDA-Rollenklasse: Quelle IEC 62764-2 (Ed. 1.0): The role class "Site" should be used for the position determination of a site. It is also used as element of a hierarchical organization. The definition of a "Site" is given in IEC 62764-1:2015, 5.3.3: "A site is a physical, geographical, or logical grouping determined by the enterprise. It may contain areas, production lines, process cells, and production units." Beispiele sind Werke. Diese Rollenklasse ist verpflichtend zu verwenden. AutomationML-Praxisempfehlung/Best Practice: AutomationML-BaseRoleClassLib/AutomationML-BaseRole/Structure/Basisstruktur
hierarchie	AutomationML-Praxisempfehlung/Best Practice: AutomationML-BaseRoleClassLib/AutomationML-BaseRole/Structure/Basisstruktur
Kinderelemente	- Enterprise - Area - Subgroupings (gem. 2.3)

Best Practice Recommendations:
ExternalDataReference
State: July 2018

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SHACL – Semantic checks for ontologies

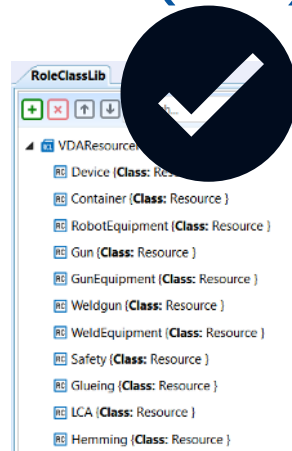
- Same as XSD for XMLs, but for ontologies
- „Shapes Constraint Language“ (SHACL)
- W3C standard for graph description
- Use case: Checking data
- Reference:
[Shapes Constraint Language \(SHACL\) \(w3.org\)](https://www.w3.org/TR/shacl/)

```
@prefix sh: <http://www.w3.org/ns/shacl#> .  
@prefix ex: <http://example.org/> .  
  
ex:CarShape  
  a sh:NodeShape ;  
  sh:targetClass ex:Car ;  
  sh:property [  
    sh:path ex:serialNumber ;  
    sh:minCount 1 ;  
  ] .
```



FD4AML: Checking your .aml step by step

Source (AML)



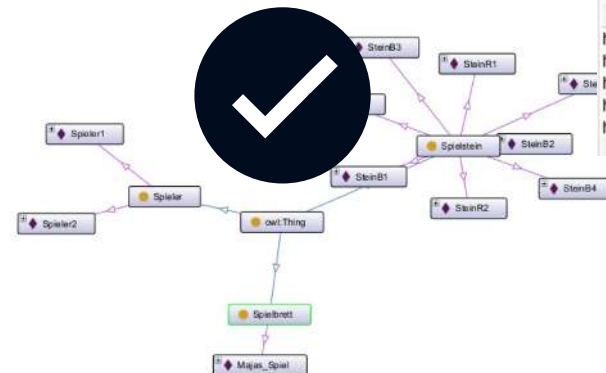
Constraints (SHACL)

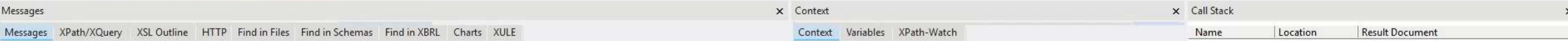
```
mod:SpielbrettProperty
  a sh:PropertyShape ;
  sh:path mod:enthaellt ;
  sh:qualifiedMinCount 4 ;
  sh:qualifiedMaxCount 4 ;
  sh:qualifiedValueShape [
    sh:class mod:Spielstein ;
    sh:property [
      sh:path mod:Farbe;
      sh:hasValue "Rot";
    ] ;
  ] ;
```

SHACL constraint violations: 5

Severity	SourceShape	Message
http://www.w3.org/ns/shacl#Violation	c749a4f3804cb9c744ab40d05e3...	Name muss Grossbuchstabe gef...
http://www.w3.org/ns/shacl#Violation	a7ddf0f169574aa295389dff4b71...	Property needs to have at least 4 v...
http://www.w3.org/ns/shacl#Violation	d2d583c520f40b62a4defb09815...	Property needs to have at least 1 v...
http://www.w3.org/ns/shacl#Violation	5c1177e524dcc5939c64776b7bd...	Property needs to have at least 1 v...
http://www.w3.org/ns/shacl#Violation	5c1177e524dcc5939c64776b7bd...	Value must be a valid literal of typ...

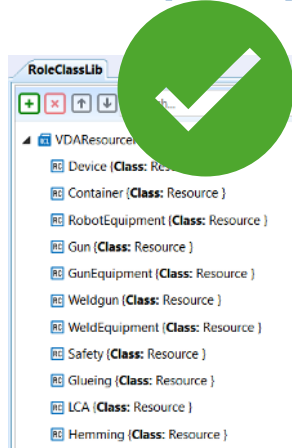
Ontologies (OWL)





FD4AML: Checking your .aml step by step

Source (AML)



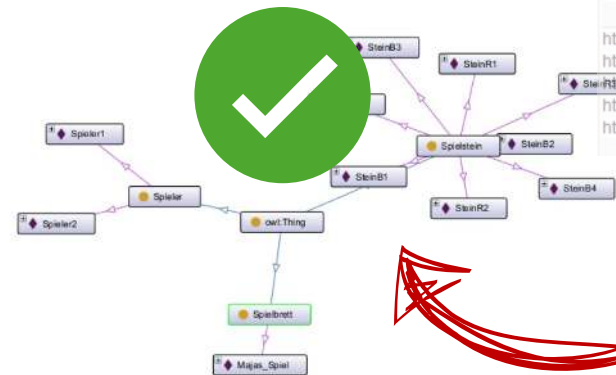
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Ontologies (OWL)



AI (RAG)



Problems – What we have to tackle in the future

Architectural

- Mapping and Check not as AML-Editor Plugin available
- No support for software to use schema

Technical

- GUIDs (used preferably for mappings) not arbitrary for every AutomationML concept.
- SHACL check currently usable only as .java application.

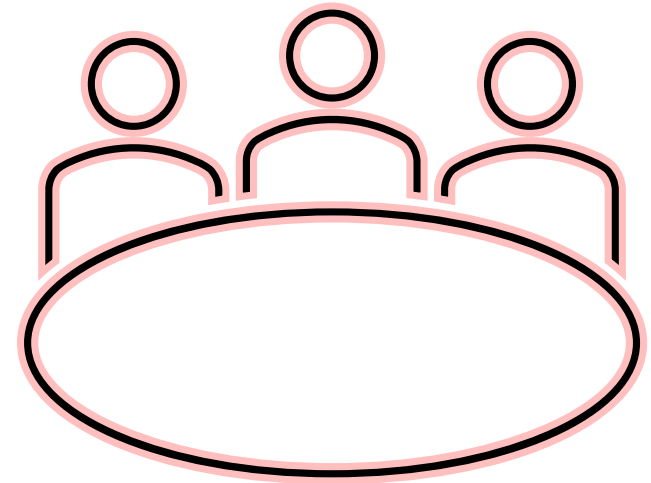
More details?

- AR Formal Description for AutomationML.
<https://www.automationml.org/wp-content/uploads/2025/09/AR-Formal-Description-for-AutomationML.pdf>
. Version 1.0.0, State September 2025.
- Philipp Wrobel: Generation of formal description for AutomationML using Large Language Models. Bachelor Thesis. Hochschule Ravensburg-Weingarten. 4.2.2025.
- Tom Westermann, Malte Ramonat, Johannes Hujer, Felix Gehlhoff, Alexander Fay: [Automatic Mapping of AutomationML Files to Ontologies for Graph Queries and Validation](#). IEEE Open Journal of the Industrial Electronics Society, 2026/3/12. 2026.
- BMWF Forschungsprojekt „DIAMOND – Digitale Anlagenmodellierung mit neutralen Datenformaten“. <https://diamond-project.de/>.
- ITEA4-Forschungsprojekt „GENIUS – Generative AI for the Software Development Life Cycle“. <https://itea4.org/project/genius.html>.

We are searching for new workgroup members!

Participants need either:

- General feeling for object oriented modelling
- Ontologies
- SHACL



We meet bi-weekly on Thursdays!

Speak to office or to us directly, if you are interested!



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