Ontology for construction quality assurance - OCQA

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Content

1. Generals about quality inspection planning
2. Ontology design
3. Inspection planning rules

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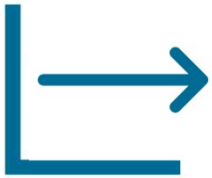
Problem definition

- Quality in construction is stagnating



- Costs due to bad quality increase

Example case study on 100 one and two family houses [1]:

- An everage of 22 defects per building
- Minimum 2 verifications are missing per building

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What´s quality assurence and what´s not?

Quality assurance is the part of quality management focused on providing confidence that quality requirements will be fulfilled. (ISO 9000)

Quality assurance includes all **measurements** to assure quality:

- Inspection planning
- Inspection execution
- Inspection evaluation

Quality assurance is **not:**

- Quality planning,
- Quality improvement
- Quality control

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Adressed research gap and aim of OCQA

Research gap:

- Focus on quality/defect recognition and evaluation
- Inspection planning is limited to check lists

Research aim:

- Provide an ontology to describe quality inspections
  - By What?, Why?, How?, How much?, Where?, …….
  - By detailed cost and time estimation
- Provide rules to support (semi-)automated inspection planning

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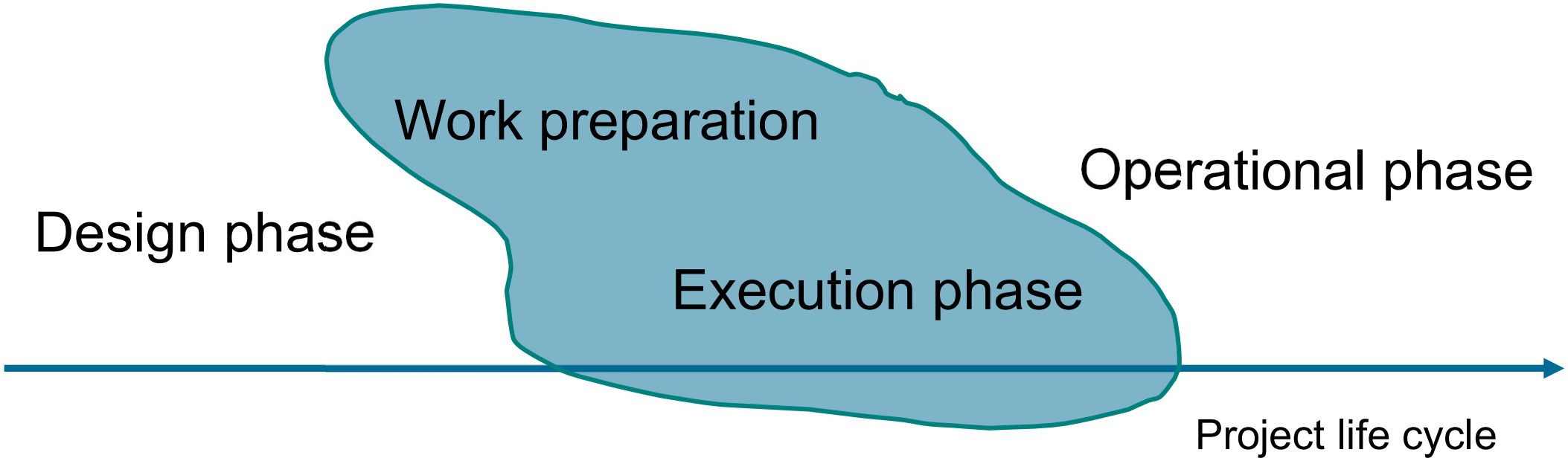
OCQA - USAGE



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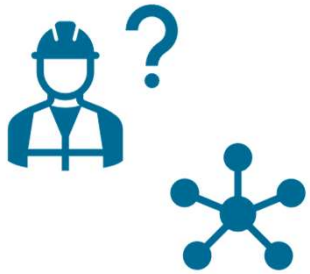
Pros of OCQA

Description of inspections

- Providing main information on inpspections
- Linking of inspections to relevant entities



Automated inspection planning

- Support for inexperienced inspectors
- Faster inspection planning
- Compliance with general and internal quality standards
- Consistent quality of inspection planning
- Automatised adaptation of the inspection planning to changes
- Integration in staff scheduling, equipment management, estimation

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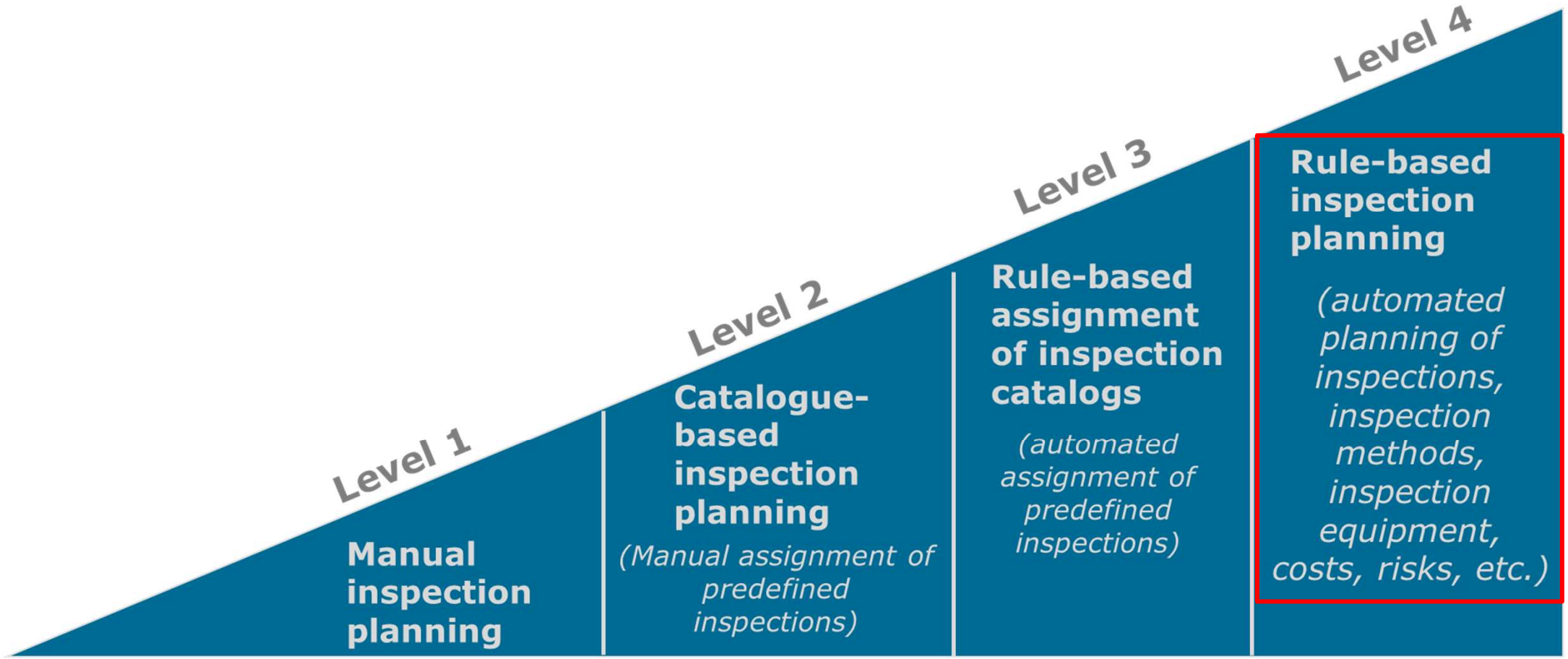
State of the art in inspection planning



OCQA design

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Which information do we need?

1. Information to plan inspections
2. Information to describe the inspection

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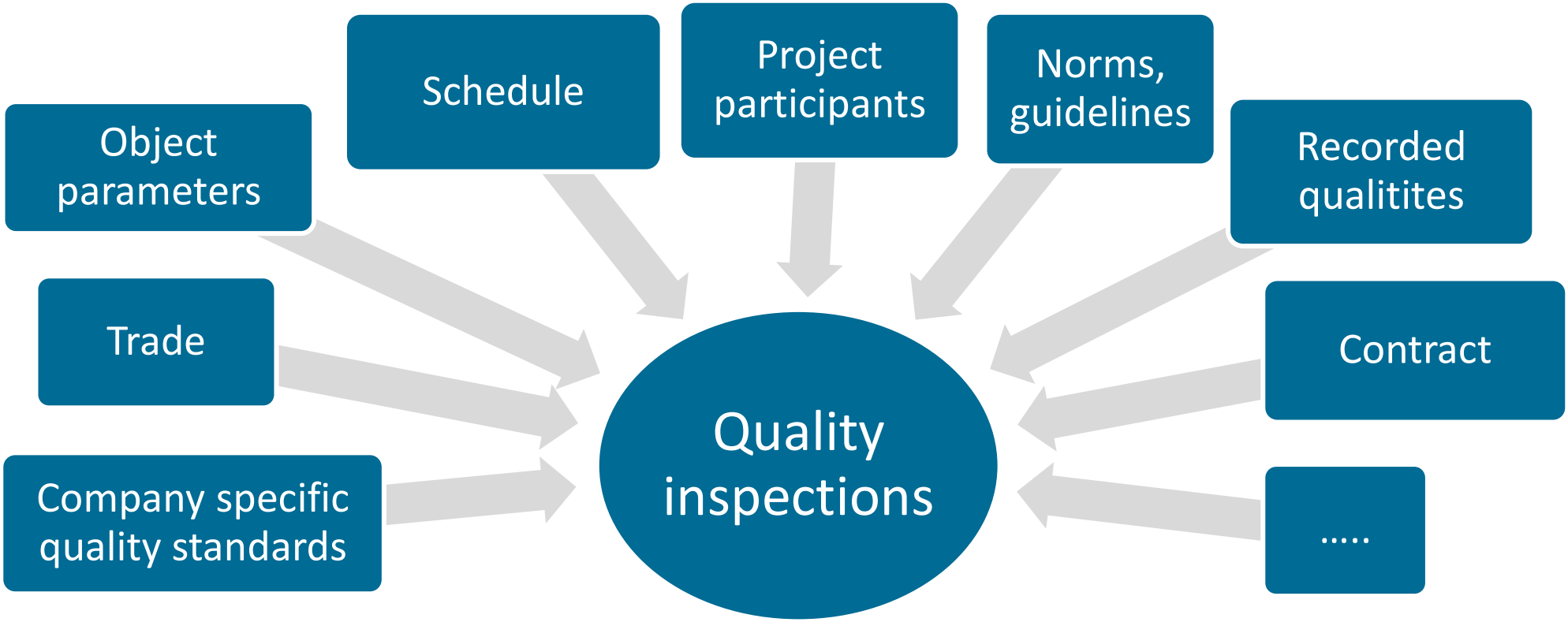

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2. **Information to describe the inspection**

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Linking of OCQA to exisintg ontologies

Before we started modelling OCQA it was important to provide already definied information by linking to other ontologies.

Three methods are identified to link ontologies:

1. **Complete import of existing ontologies**
2. Partial import of existing ontologies
3. **Alignement to existing ontologies**
4. … ?

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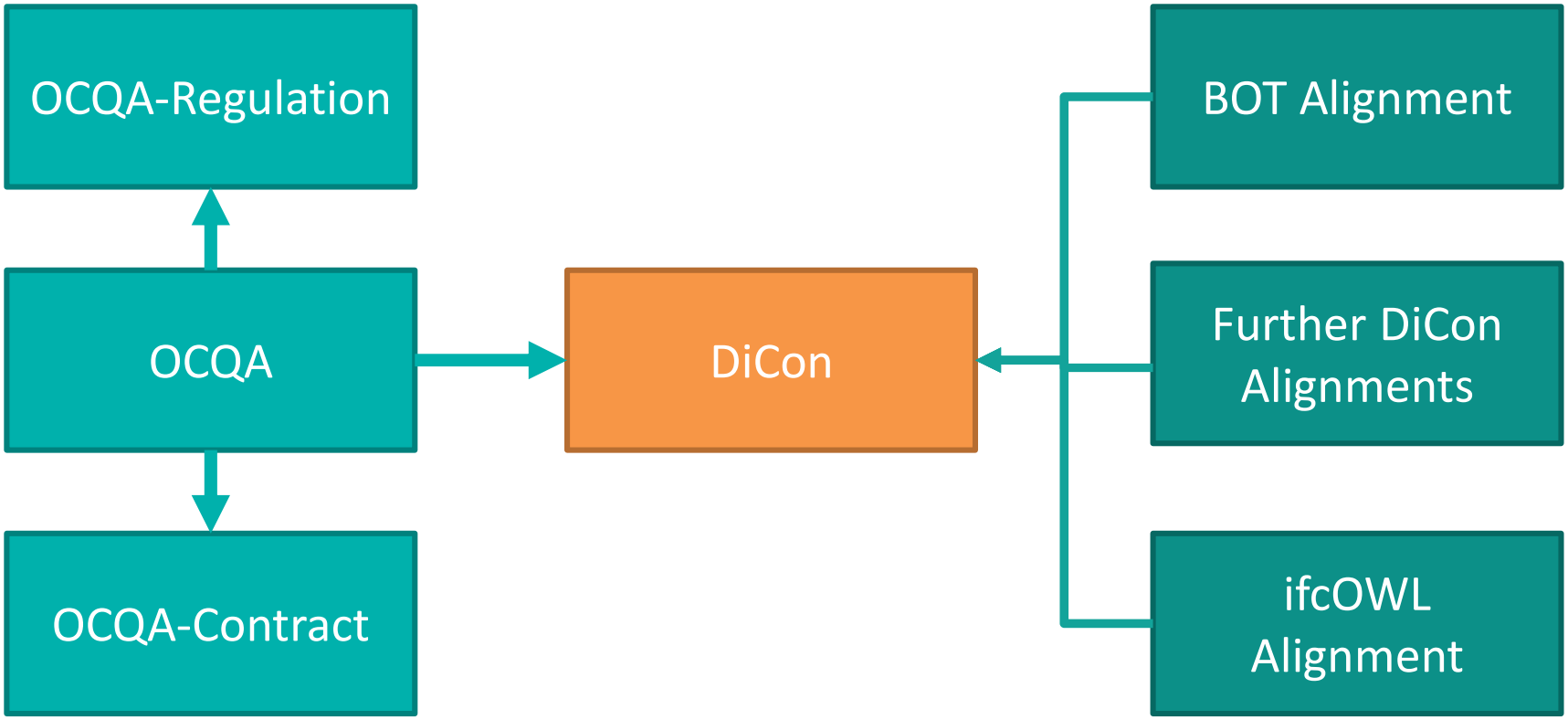
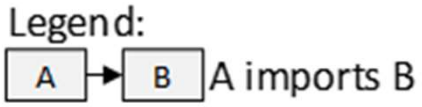
Linking of OCQA to exisintg ontologies





https://digitalconstruction.github.io/v/0.5/

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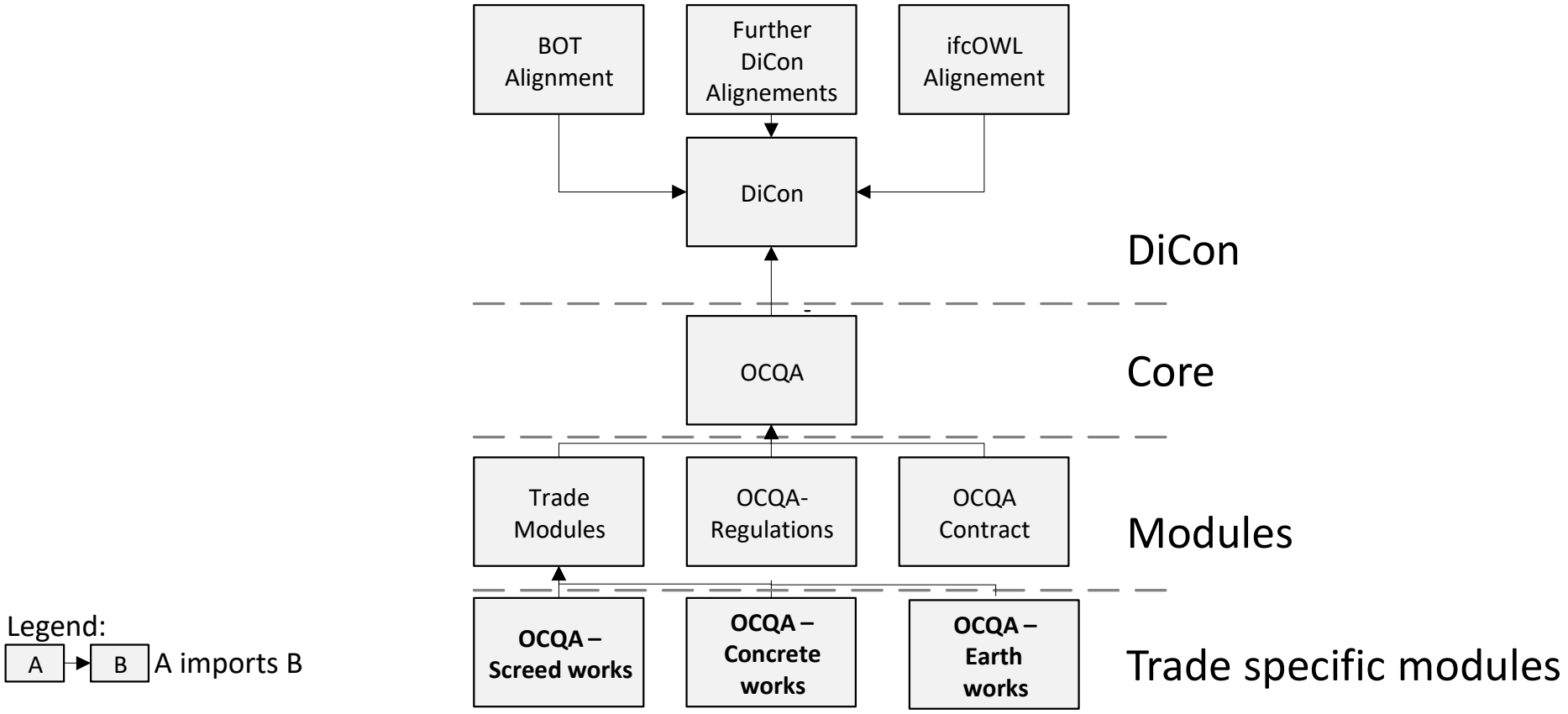
Modules of OCQA



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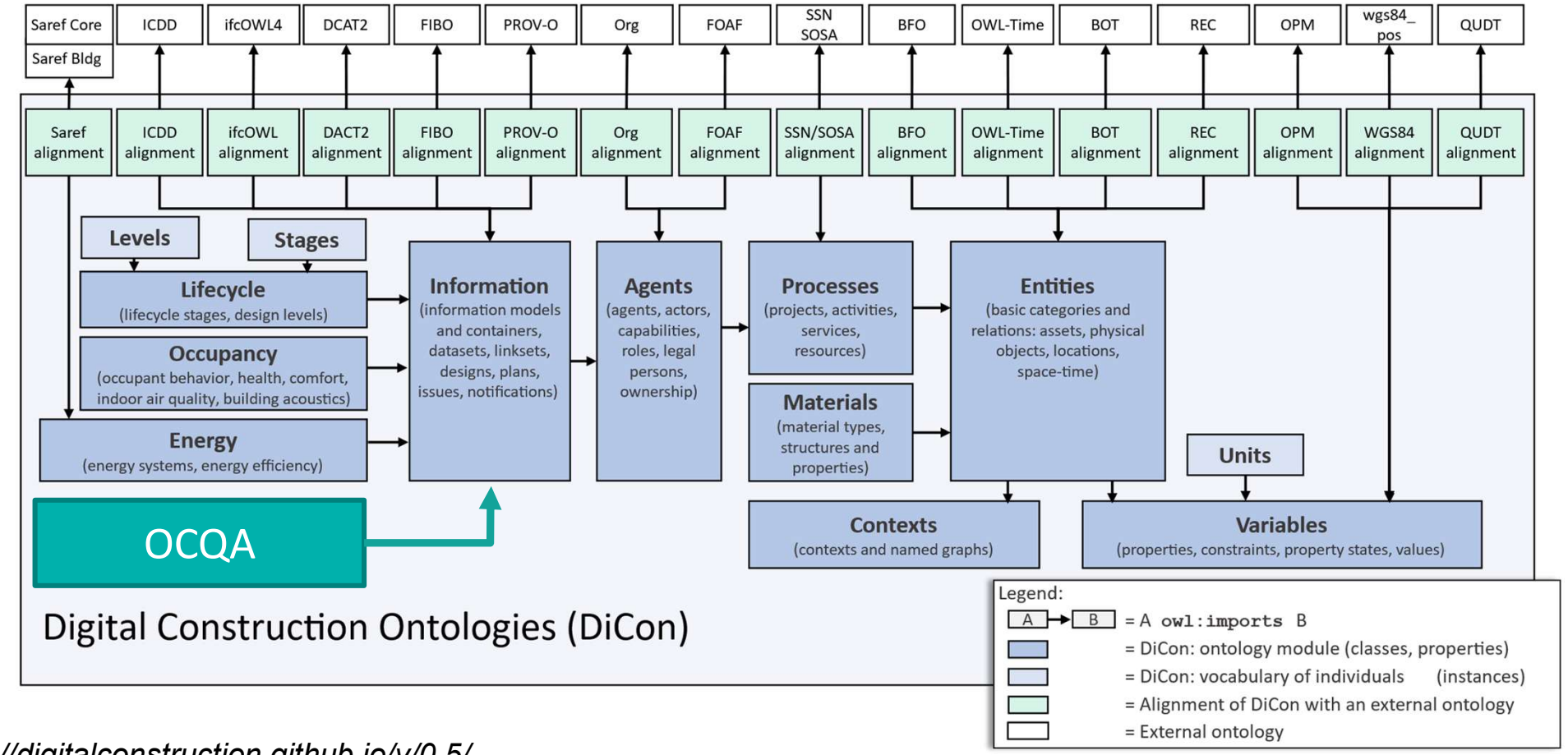

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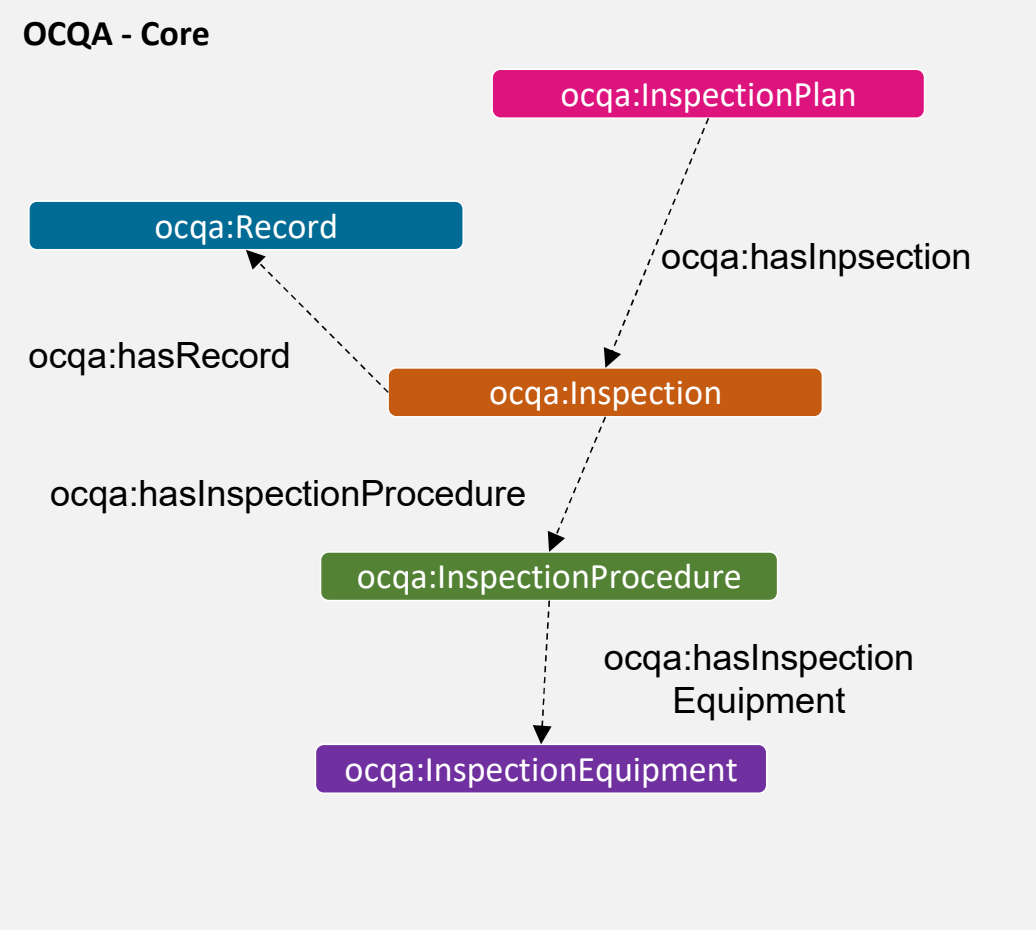
How does it look now?



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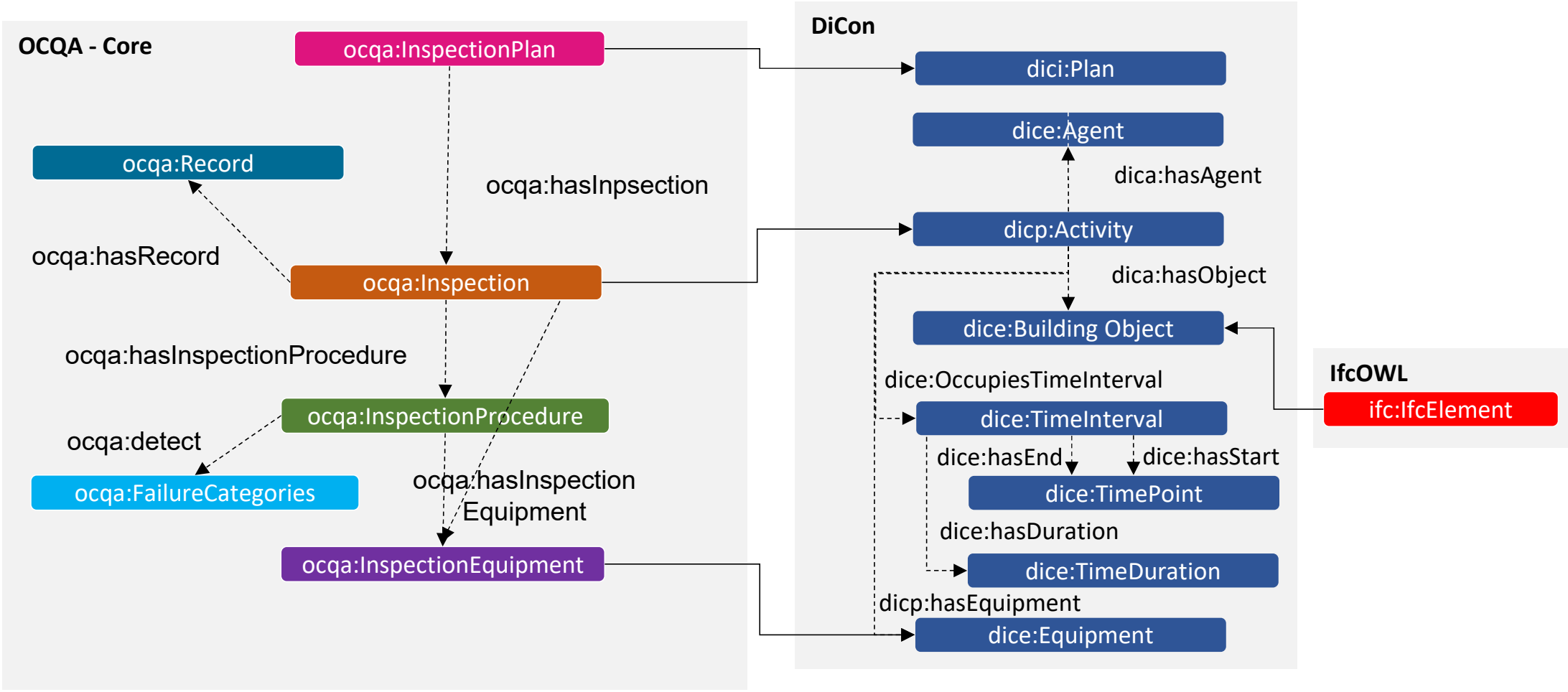
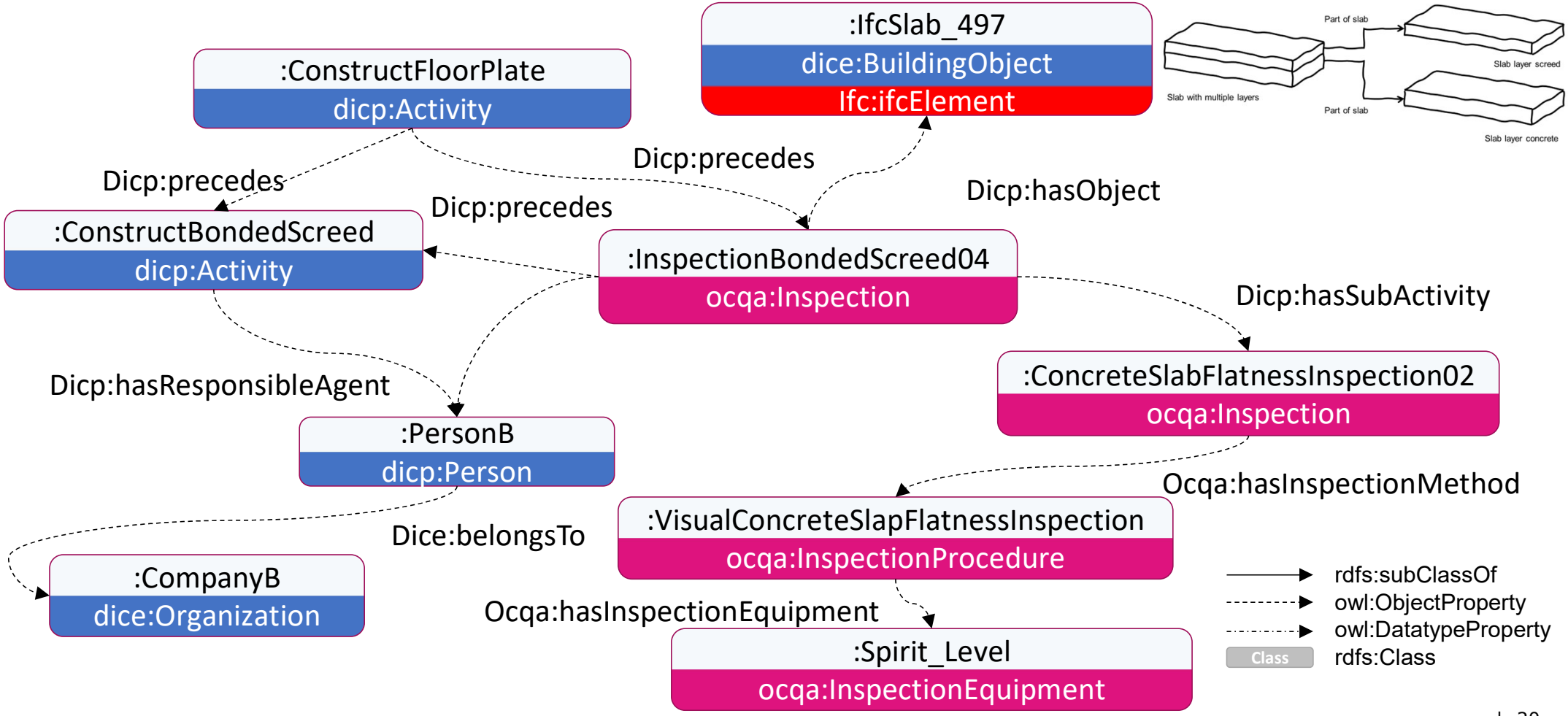
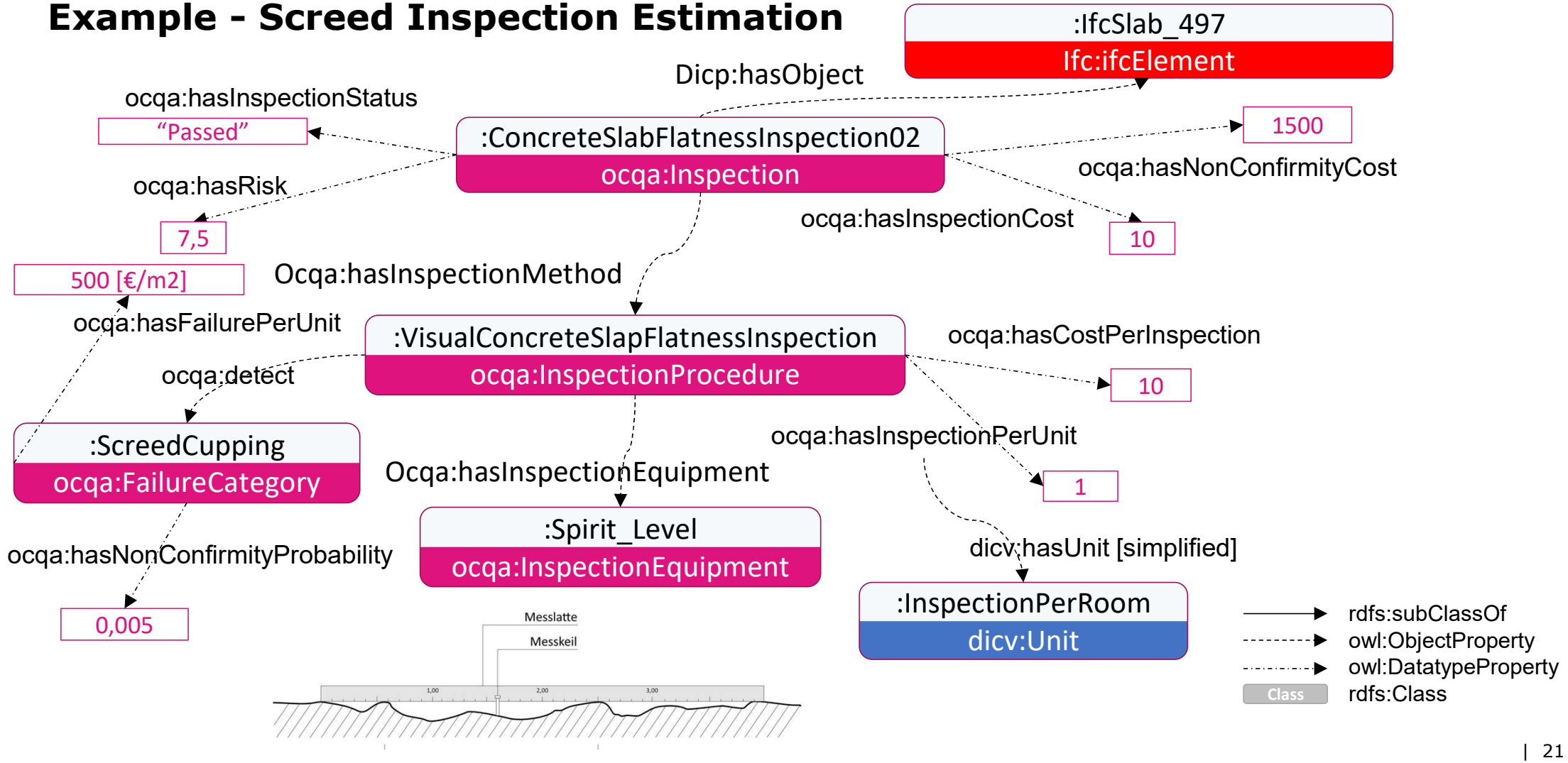


Example - Screed Inspection



Example - Screed Inspection Estimation



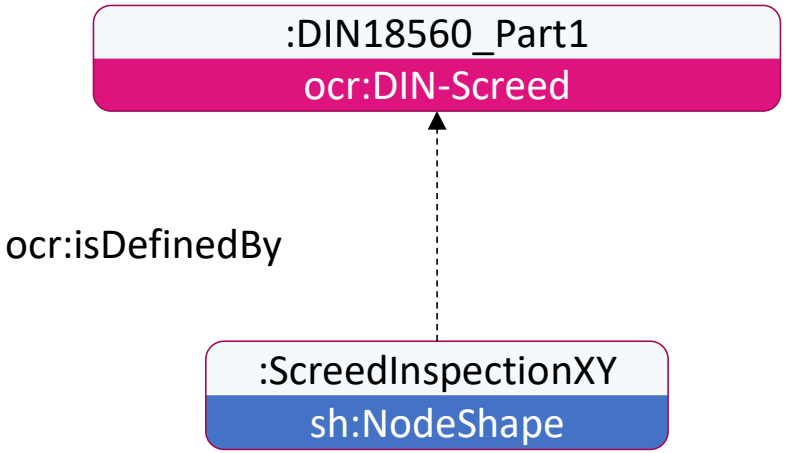
SHACL - Rules

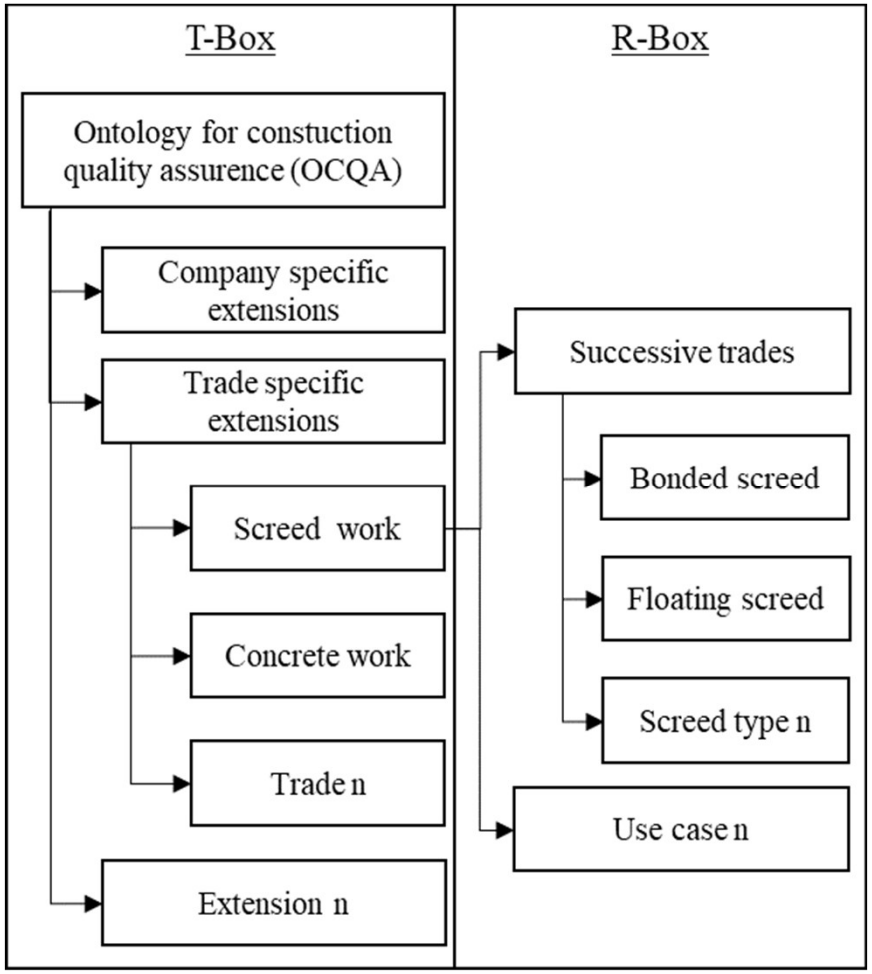
To provide basic constrains and inference logic the rules are formulized in **SHACL**:

- SHACL is a validation language and defined as
  - SHACL https://www.w3.org/TR/shacl/
  - SHACL Advanced Feature https://www.w3.org/TR/shacl-af/
- Standardized by W3C
- Enables modularization (is stored in rdf)
- Accessing of SPARQL

SHACL rule modularization

- The rules defined in SHACL can be modulized by defining an own namespace
- Furthermore the rules can be linked to the „source" of the rules (regulation or contract)





Difference general rules and special rules

1. General rules

Are used to provide simple constrains:

- Each object and each activity need min. one inspection (Not possible with open world assumption)
- Each inspection should have min. and max. one inspection procedure

Are used to derive general knowledge:

- The start time of an inspection is the end time of the predecessor and will be used to estimate costs and risks for inspections

2. Specific rules

Are used to infer new inspections, inspection procedures …..

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Example for a specfic rule:

```
1.  ocqa_screed:VisualInspection screed
2.  a sh:nodeShape;
3.  sh:targetClass [IfcSlab]
4.  sh:condition [
5.      [Condition1_ Slab contains layer of concrete]
6.      [Condition2_Slab contains layer of screed]
7.      [Condition3_Slab contains activity screeding]
8.      [Condition4_Slab contains activity concreting]
9.  ];
10. sh:rule [
11.     a sh:TripleRule ;
12.     sh:subject sh:this;
13.     sh:predicate rdf:hasInspection;
14.     sh:object [URI-Generierung für Prüfaktivität];
15. ];
```

Get all relevant objects

Check conditions of slab

Execute Rules

Conclusion and further steps

Semantic web standards enable:
- A detailed description of inspections
- An automated planning of inspections

But implementation of specific SHACL rules :
- Requires expert knowledge
- is complex and time-consuming

Further implementation steps:

- Ontology evaluation based on focus group interviews
- Development of SHACL-Rules to infer new SHACL-Rules based on decision tables
- Development of SHACL-Rules to do
    - Cost planning
    - Risk estimation

Questions?

Thanks for your attention and have a nice afternoon!