SVAR – Systematic Verification and Acceptance of Requirements

Reference group meeting

June 18, 2024

Reference group

Pia Schönbeck – Sponsor. Project lead in systemic requirement management.

Oskar Permwall – Specialist in systemic requirement management

Marit Jidemo – Business developer in information management.

Erik Häggström – Area responsible (Background in BIM/GIS, information management in BIM

Rastkar Rauf – technical engineer, Digital project management

Susanne Van Raalte – BIM strategist

Karin Anderson – BIM specialist

Agenda

- Progress report
  - Objective 1: ACC Capability Maturity Model
  - Objective 2: TRVInfra requirements verifiability
  - Objective 2: Machine readable formats for requirements
- Synergies with other ongoing projects in Trafikverket
- Reminder about “Champions”

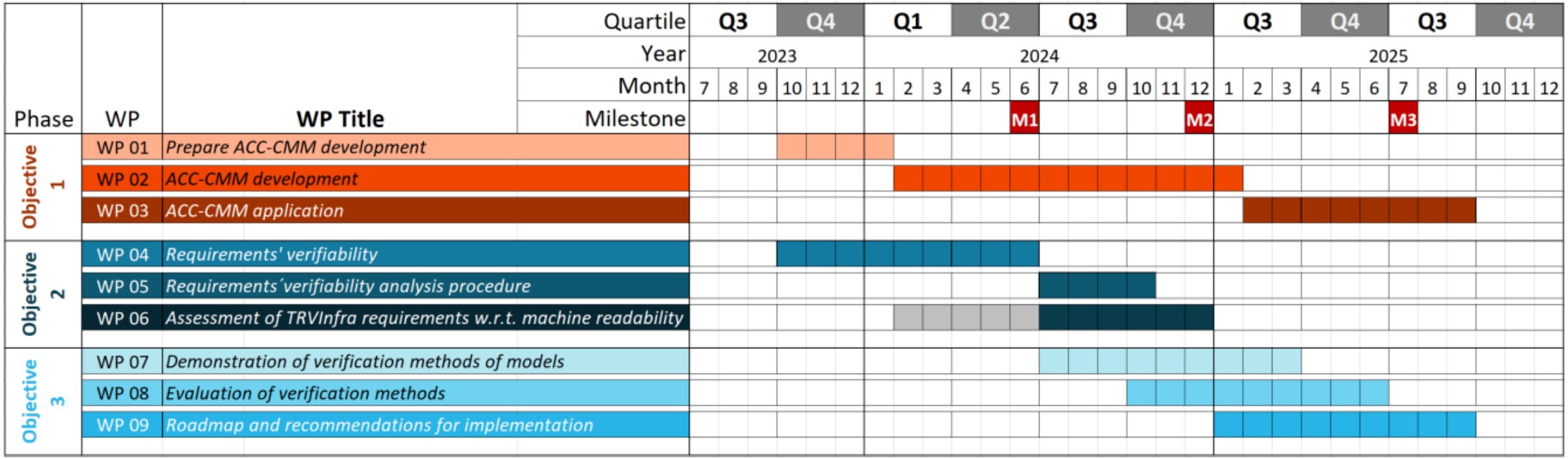
Project overview

Duration: October 1, 2023 – September 30, 2025

Three objectives, each with three work packages.

- **Objective 1:** Development of an Automated Compliance Checking Capability Maturity Model (ACC-CMM)
- **Objective 2:** Understand to what degree the compliance checking of requirements (TRVInfra, project-specific) is automatable
- **Objective 3:** Develop procedures for automated, reusable, verification of requirements

Project Schedule



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ACC Capability Maturity Model

Current: Initial version developed June 2024 [WP02]

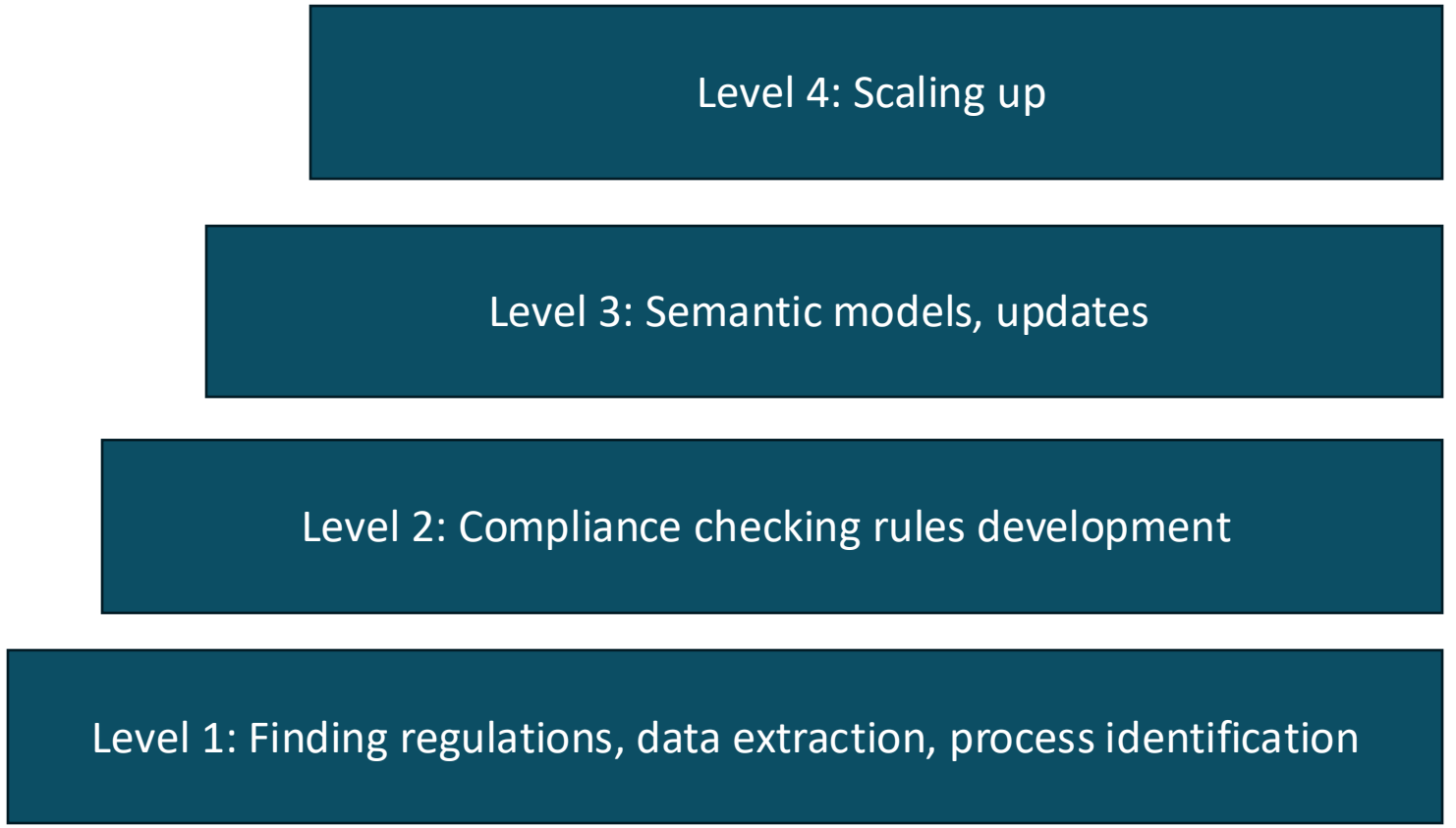
Current: Work on consistency and relationships between the stages and activities

Next Steps: Planned interviews with TRV and Hochtief in August 2024

Next Steps: Focus on completeness

Next Steps: Fit for purpose

Next Steps: Dissemination



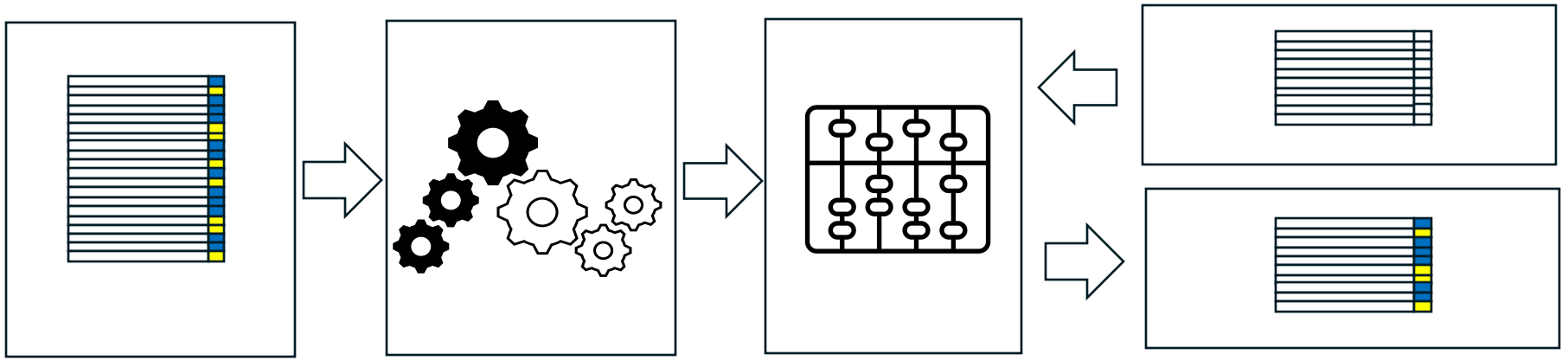
TRVInfra requirements verifiability

Three topics:

- Requirements verifiability dimensions [WP04]
- Data set creation and model training [WP05]
- Next steps

Reminder: Next steps from last time

1. Determine a classification system based on what we found in literature.
    - Challenge: data set size. The more categories we have, the more training samples we need.
    - Possible solution: weakly-supervised learning (fewer training data needed)
2. Create a training data set
    - I'm confident that this can be done by BTH/HTV. No deep domain knowledge required.
3. Train and evaluate the model
    - Blueprint from recent papers (e.g. Zheng et al. 2024)



Training data

Learning algorithm

Deep neural network classifier

Trained model

Large Language Model: BERT (Swedish).

Predictions

Requirements verifiability [WP04]

Synthesis from several scientific studies; 7 dimensions:

- Target: product, process, documentation
- Nature: qualitative, quantitative, mixture
- Interpretability: non-ambiguous, ambiguous (natural), ambiguous (artificial)
- Element: yes, no
- Reference: local, internal, external, none
- Logic rule: yes, no
- Rule complexity: class 1 - 4

Classifier training [WP05]

- Ongoing: setup of annotation platform
- July: pilot and test
- August/September: data collection
- September/October: training and evaluation

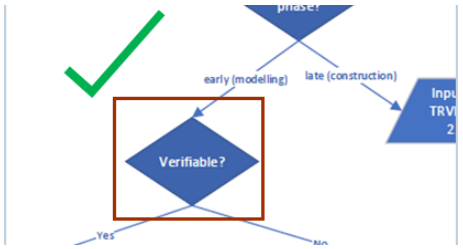
Deliverables

1. WP04 [June]: A definition of requirements verifiability (we identified 7 dimensions that characterize verifiability)
2. WP05 [October]: Guidelines and the software to conduct the analysis (on new requirements).
3. WP06 [December]: A classification of all (complete) TRVInfra requirements according to target, nature, interpretability, reference, and logic rule.

Work Package 6
Current Approach / Activities

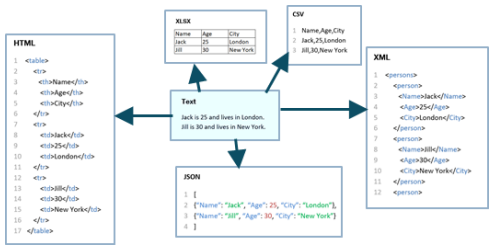
Work Packages 4/5
(Input)

List of verifiable Requirements



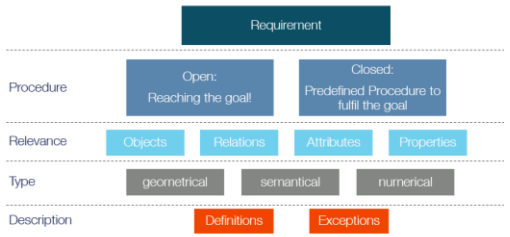
Work Package 6

Methods to make Requirements machine readable



Work Package 7/8
(Post-Processing)

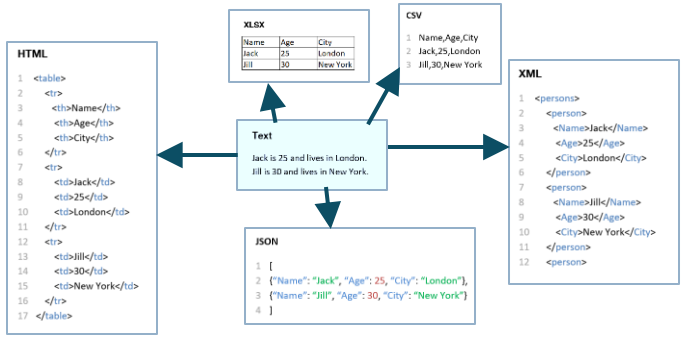
Proof of Concept for Verification



Work Package 6
Machine Readability – Methods for Transformation

Work Package 6

Methods to make Requirements machine readable



How to make List of Requirements machine-readable?

Overview Methods for Data Processing

General

OCR (Optical Character Recognition)
Speech Recognition
Data Extraction Tools
Manual Data Entry
NLP (Natural Language Processing)
RASE (Requirements, Applicability, Selection, Exception)
...

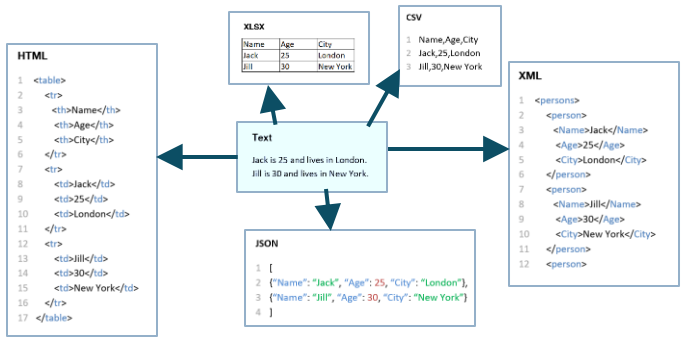
IFC Relevance

mvdXML
Rule Table
BIMRL (Rule Language)
IFC Constraints Model
...

Work Package 6
Machine Readability – Methods for Transformation

Work Package 6

Methods to make Requirements machine readable



How to make List of Requirements machine-readable?

Findings / identifying suitable approaches:

Challenges
- Content/Layout/References are very different
- No fixed/defined places where to find these information
- No defined file-formats the requirements are referring to

Consequences

Manual translation
- ➡ lot of efforts
- ➡ prone of errors

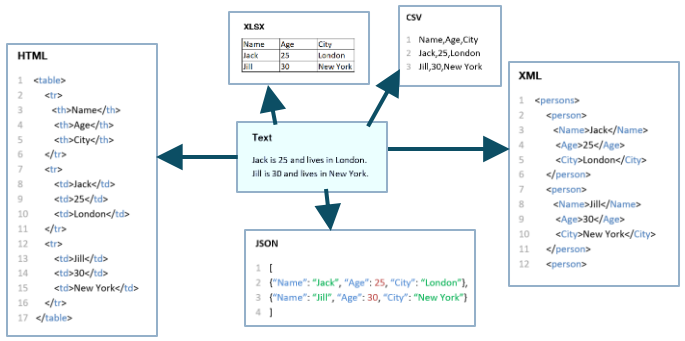
Translation by AI
- ➡ lot of training material required

Possible Approach: Create Ontologies / Linked Data

Work Package 6
Machine Readability – Methods for Transformation

Work Package 6

Methods to make Requirements machine readable



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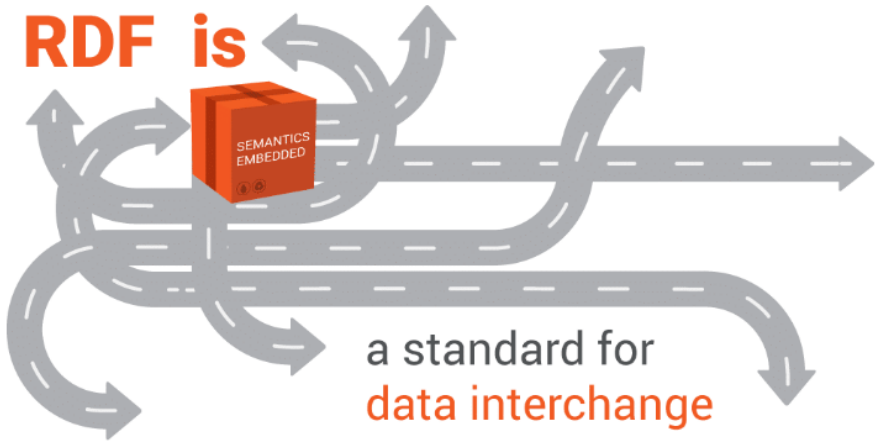
RDF (Resource Description Framework)

RDF – Resource Description Framework



Infobox

RDF Quick Facts

- ***What is the Resource Description Framework (RDF)?***

RDF is a general method of describing data by defining relationships between data objects.

- ***Why is RDF a simple and flexible data model?***

RDF enables effective data integration from multiple sources, detaching data from its schema. This allows multiple schemas to be applied, interlinked, queried as one and modified without changing the data instances.

- ***What is RDF built around?***

RDF is built around the existing Web standards: XML and URL (URI).

Source: Ontotext Fundamentals Series

RDF – Resource Description Framework

Purpose

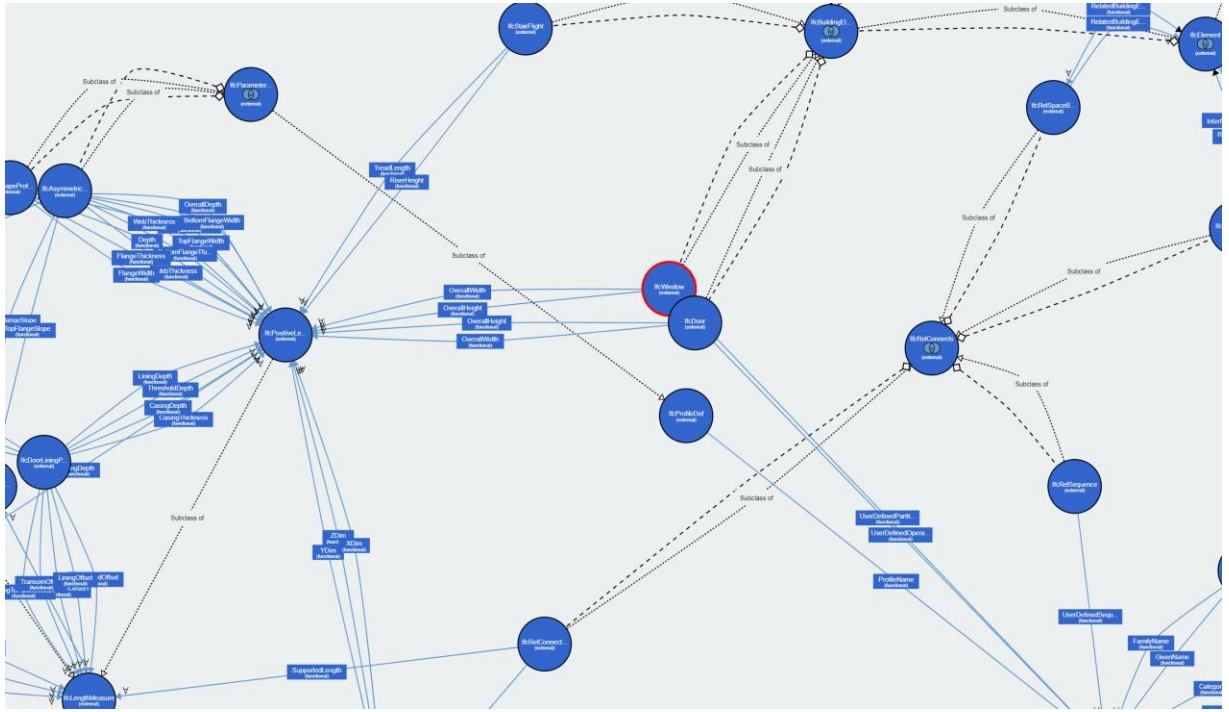
- To provide a structure (framework) for describing identified things (resources, classes)
- Identification in a unique way
- Describing Relations

➡ **Simple Statements in Form of Triples**
Subject > Predicate > Object

Examples

Wall > is subclass of > ífcBuildingElement;
Wall > has > Door;
Door > belongs to > Room;

➡ AEC data can be described in RDF:
e.g. IfcOWL



Source: BIMiB Project @Hochschule Bielefeld, HOCHTIEF ViCon

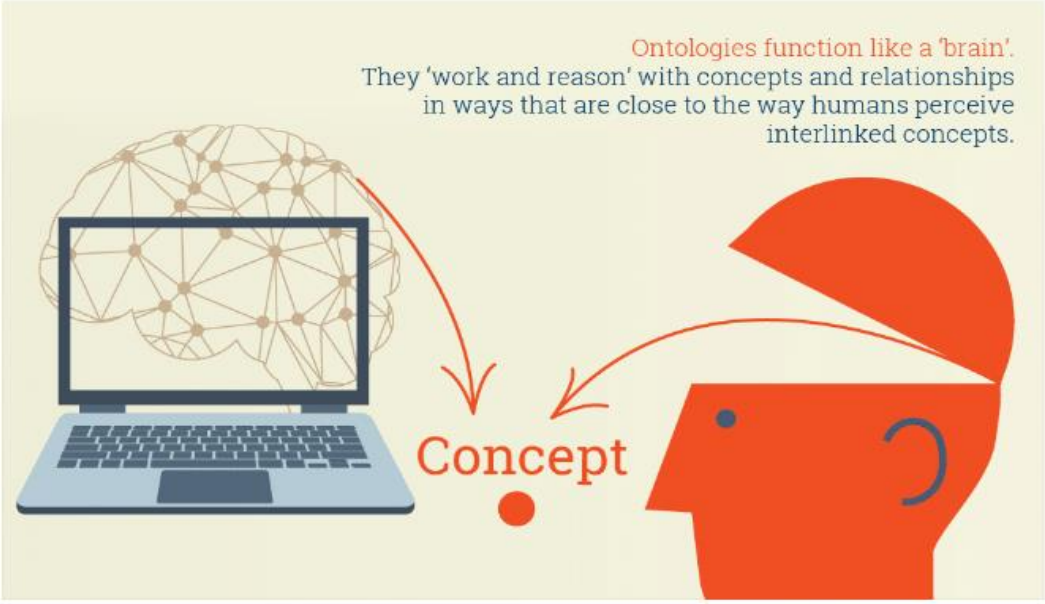
The OWL Standard

OWL

- Semantic web computational logic-based language
- Represents rich and **complex knowledge** about things and **relations** between them
- Provides **meaningful distinction** between classes, properties and relationship
- Outlines **equivalences** and **differences** between instances, classes and properties
- Enables concepts to be used differently and **interlinked**
- Ensures **disambiguation**

➡ **Enabling automated reasoning of data**

Wall > is subclass of > ifcBuildingElement;
Wall > has > Door;
Door > belongs to > Room;



Source: Ontotext Fundamentals Series

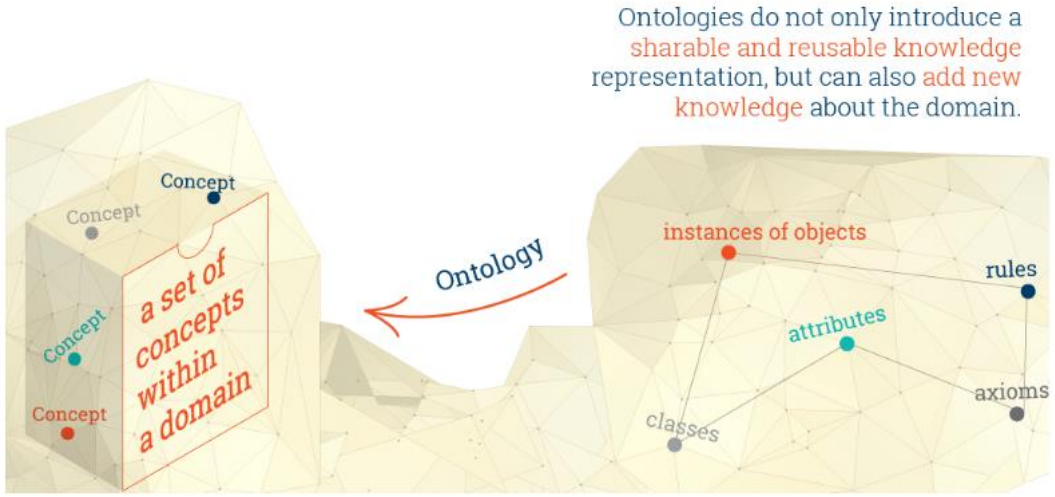
Ontologies – Linked Data Approach

"An ontology is a formal description of knowledge as a set of concepts within a domain and the relationships that hold between them."

Ontologies
- Provide possibility to **link one piece of information to other pieces of information**
- Enable **database interoperability** and **cross-database search**
- Ensure **common understanding** of information

➡ **Lead to smooth knowledge management**

➡ **Enhance data quality**



Source: Ontotext Fundamentals Series

Querying - A mechanism for compliance checking

Start a query ➡ get an answer

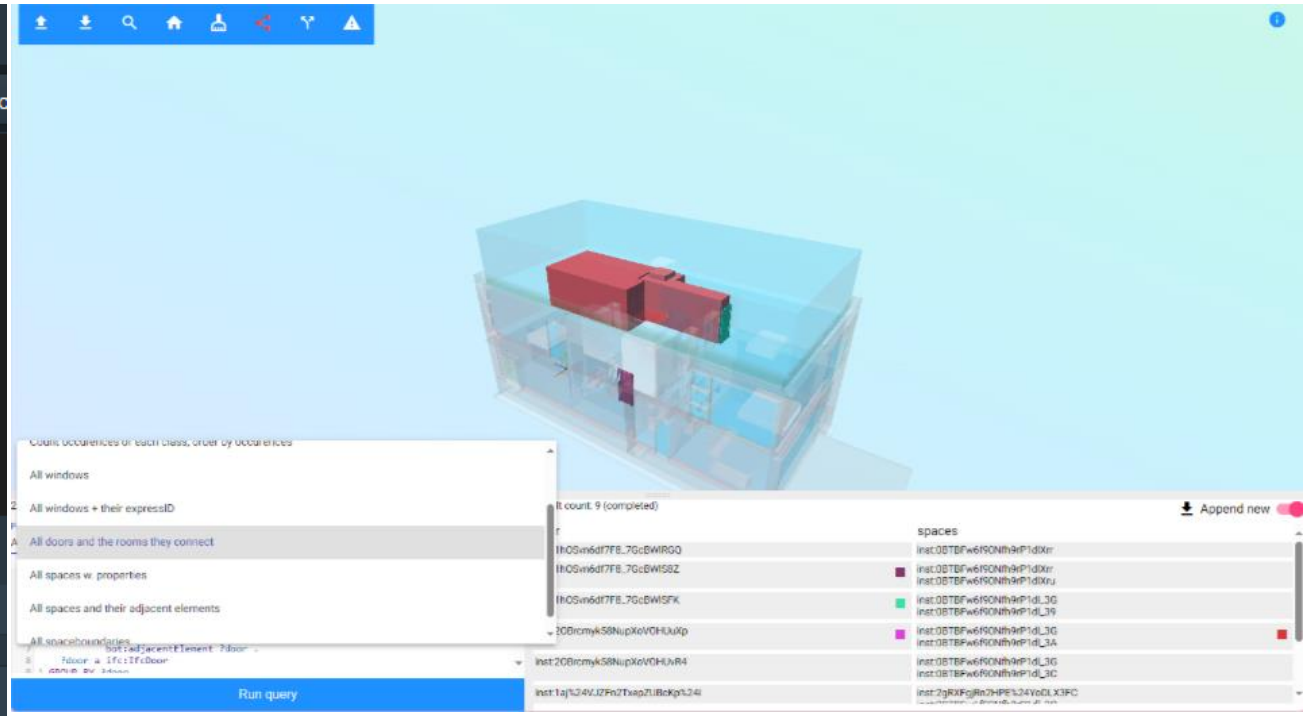
Query-1

Run | Show Plan | Reasoning | svar | stardo

```
1  PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
2  PREFIX owl: <http://www.w3.org/2002/07/owl#>
3  PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
4  PREFIX svar: <http://www.viconbim.com/svar/>
5  SELECT ?req ?ref ?label
6  WHERE {
7   ?req a svar:Requirement ;
8      svar:hasExternalReference ?ref .
9   ?ref rdfs:label ?label .
10 }
11
```

Run to File | Text | Charts | 1 Results, 420 ms

req	ref	label
svar:requirement_1c68acb1-9f94-4e38-890f-e9d800dc05...	svar:external_classification	"SS-EN 12899-3"



Source: HOCHTIEF ViCon, LD-BIM viewer by Mads Holten Rasmussen and Alexander Schlachter with the support from NIRAS A/S

Objective 3
Upcoming Activities

Work Packages 7
(Demonstration)

Choose five requirements
- Different classified requirements
- Referring to different file types

Example:
- Create suitable Ontology
- Identify information in document
- Identify information in model

Verify Requirement
- Via Ontology approach

Work Package 8
(Evaluation)

Use this verification methods
- for IFC, Excel, PDF, etc.
- PoC for Ontologies

Create several Checks
- based on Ontologies

Combine several Examples

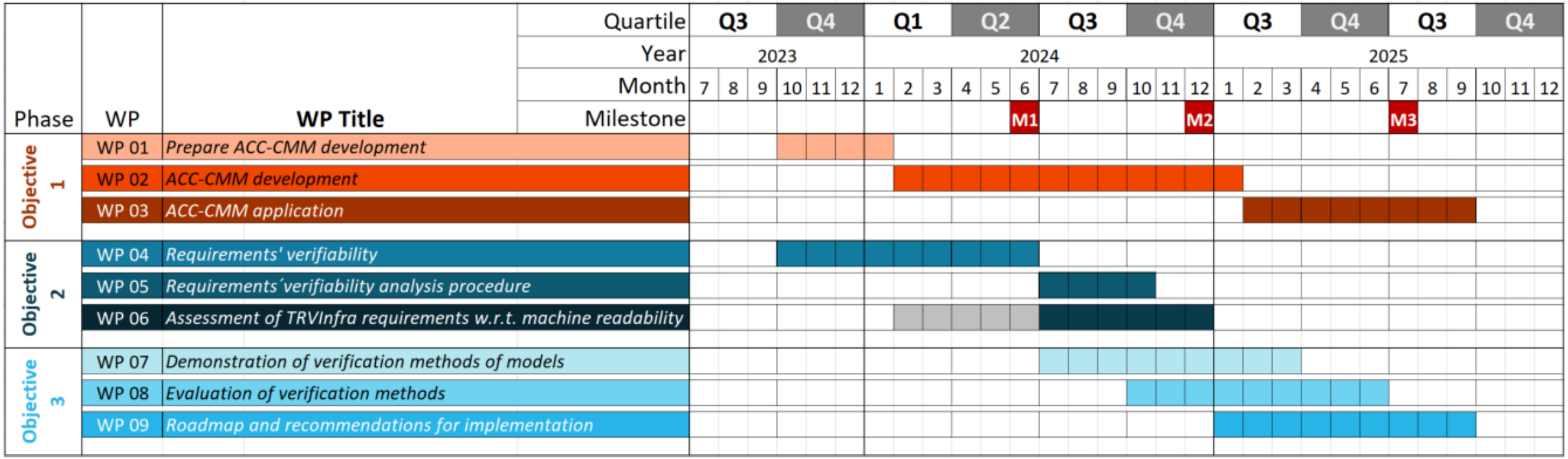
Work Package 9
(Recommendation)

Summary of all achievements
- Processes
- Examples
- Demonstrators

Possibilities and Opportunities
- Proof of Concepts
- Identified Benefits

Requirements for implementation
- What is missing?
- What needs optimization?
- Where to (possibly) integrate AI?

Project Schedule



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Synergies with other projects

- Upcoming:
  - Förstudie: Intelligent lösning för kvalitetssäkrad livscykelhantering av krav (Jesper Kornestedt)
- Potential:
  - Vinnova, under the umbrella program of advanced digitalization: research project with Celeris (Anders Ekman), BTH and Trafikverket.

Champions for project outcomes

Motivation: critique from previous research projects that results are not transferred to TRV

Idea: have one person from TRV "champion" the results and drive dissemination/adoption in TRV *after* the project

Goal: find in 2024 champion(s), based on the results we achieve.

Ambition: start in 2025 with dissemination/promotion, before the project ends in September

Next steps

- Summary of action points for All
- Date for next reference group meeting


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