SVAR – Systematic Verification and Acceptance of Requirements

Reference group meeting

January 31, 2025

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 3: Demonstration of verification methods
- Synergies with other ongoing projects in Trafikverket
- Reminder about “Champions”

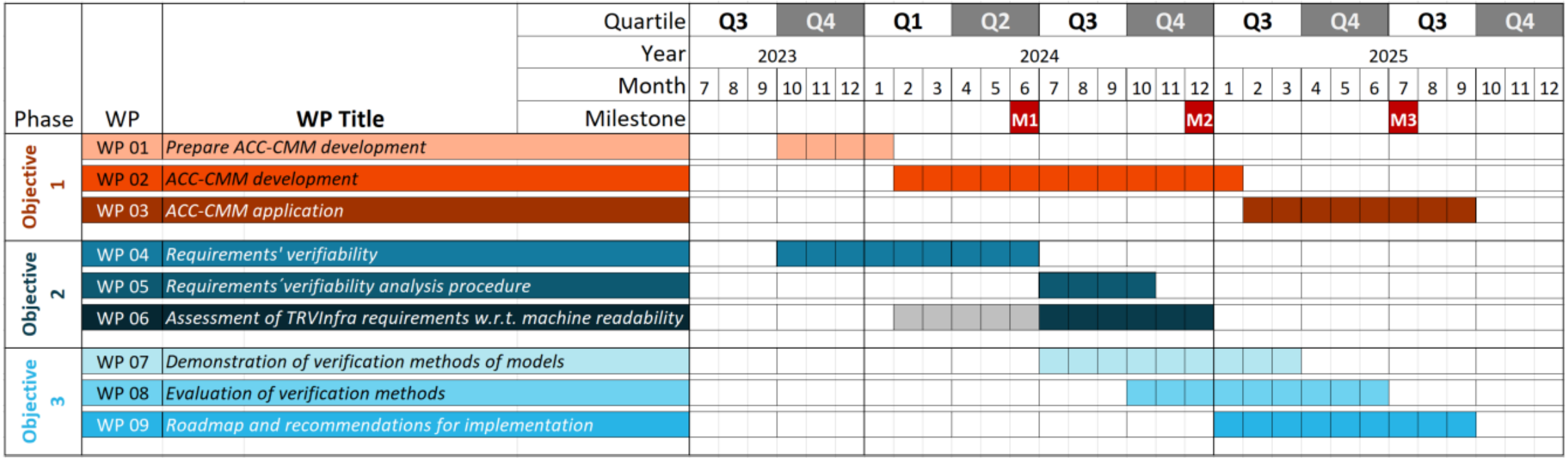
Project overview

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



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

Objective 1: ACC Capability Model

ACC Capability Maturity Model

Done: Developed the model and discussed internally at BTH

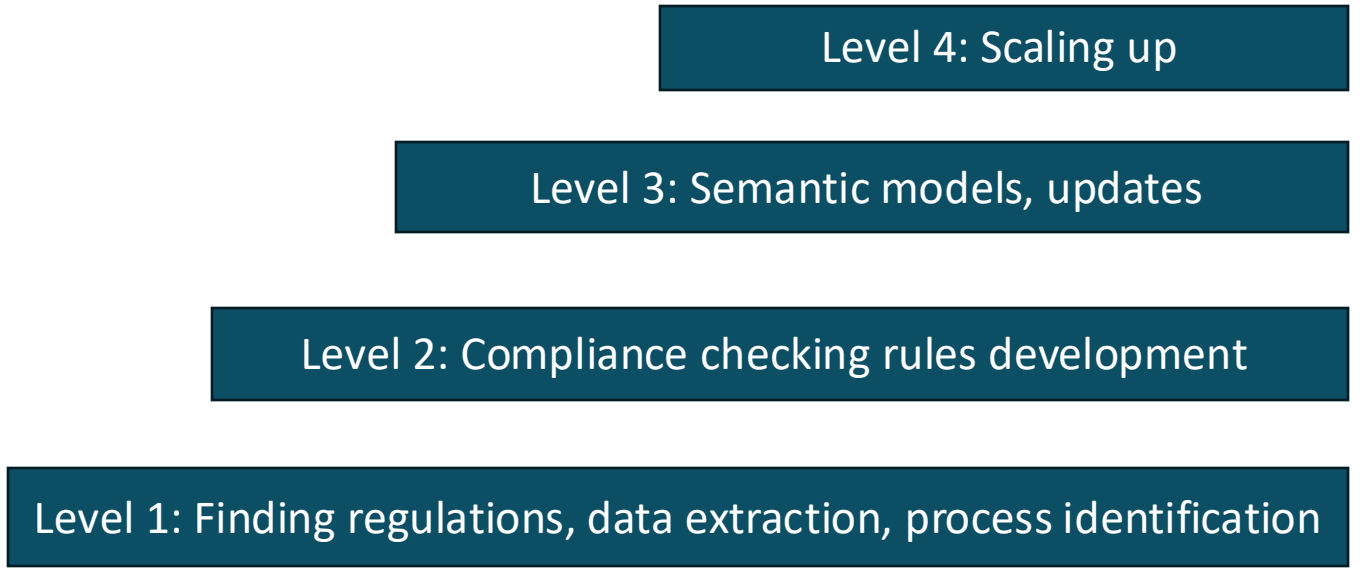
Done: Analyzed how the model fits into other Digitalmognad initatives

Current: Interviews with TRV (list provided by Susanne)

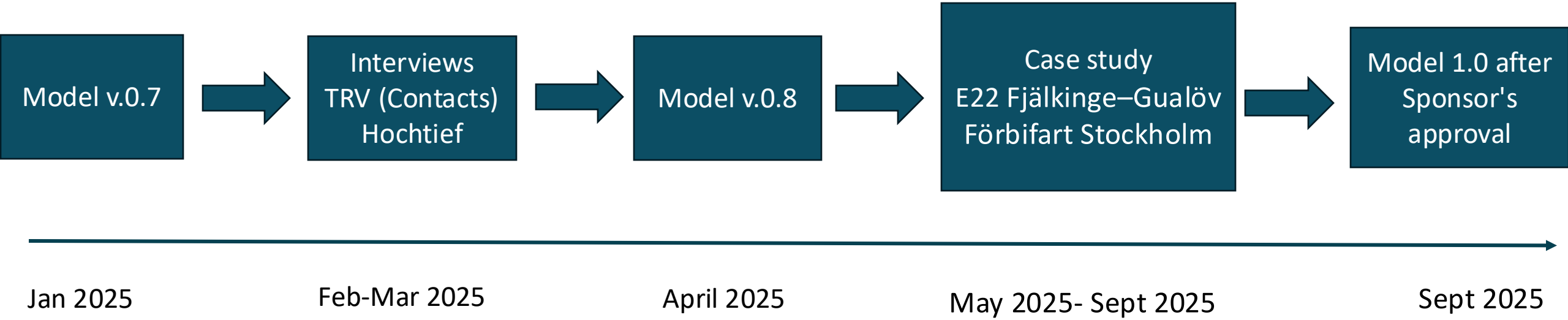
Current: Interviews with HOCHTIEF

Next steps: Select a "case study" project to apply the ACC CMM model

- Förbifart Stockholm ?
- E22, Fjälkinge–Gualöv?



ACC CMM Model Evaluation



Objective 2: TRVInfra requirements verifiability

TRVInfra requirements verifiability

Purpose: We perform the classification to judge how verifiable the TRVInfra requirements are.

Approach: Classify requirements along 5 dimensions (target, nature, interpretability, reference, logic rule)

Goal: Create a ground truth to train a classifier (deep learning) to predict verifiability of 18.000 TRVInfra requirements

Classification status

- In 2 rounds with independent judges, classified 72 requirements
- Validation of classification with Trafikverket (started yesterday)
- Implemented the classifier and published here: https://github.com/bth-dipt-research/SVAR

Preliminary results

Cross-validation (k=10) with 72 data points

	Accuracy	Variation	Confidence interval
Target	85.9%	6.4	82.7% - 89.1%
Nature	86.4%	11.6	80.6% - 92.2%
Interpretability	63.9%	9.0	59.4% - 68.4%
Reference	84.8%	7.2	81.2% - 88.4%

Interpretation:

- Excellent performance with very little data
- Interpretability is the most difficult dimension
- Larger ground truth likely to improve results

Validation of classification

- Reviewers: Oskar Permvall, Martin Lundberg
- Focused on the difficult classifications (interpretability)
- Validated 72 out of 288 classifications
- Identified 8 changes (all in "interpretability") to the ground truth
- Next step: schedule online workshop with Oskar and Martin to review the remaining, "easy", classifications

Next steps

- Increase the data for training
- Continue the validation of the classification with Trafikverket
- Once we achieve 90%+ accuracy, classify whole TRVInfra dataset (18.000) requirements [WP04]
- Use chatGPT or IBM's PoC to reformulate non-verifiable requirements [WP04]
- Document software and usage instructions [WP05]

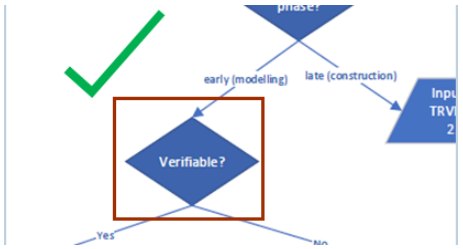
Objective 2: Machine-readable requirements

Objective 3: Demonstration of verification methods

Work Package 6
Current Approach / Activities

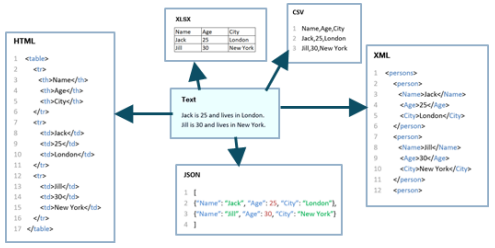
Work Packages 4/5 (Input)

List of verifiable Requirements



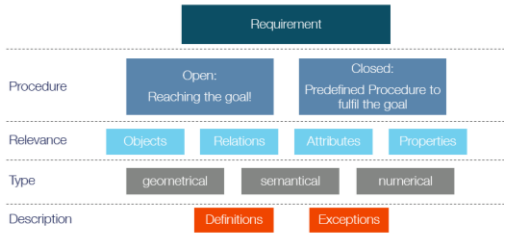
Work Package 6

Methods to make Requirements machine readable

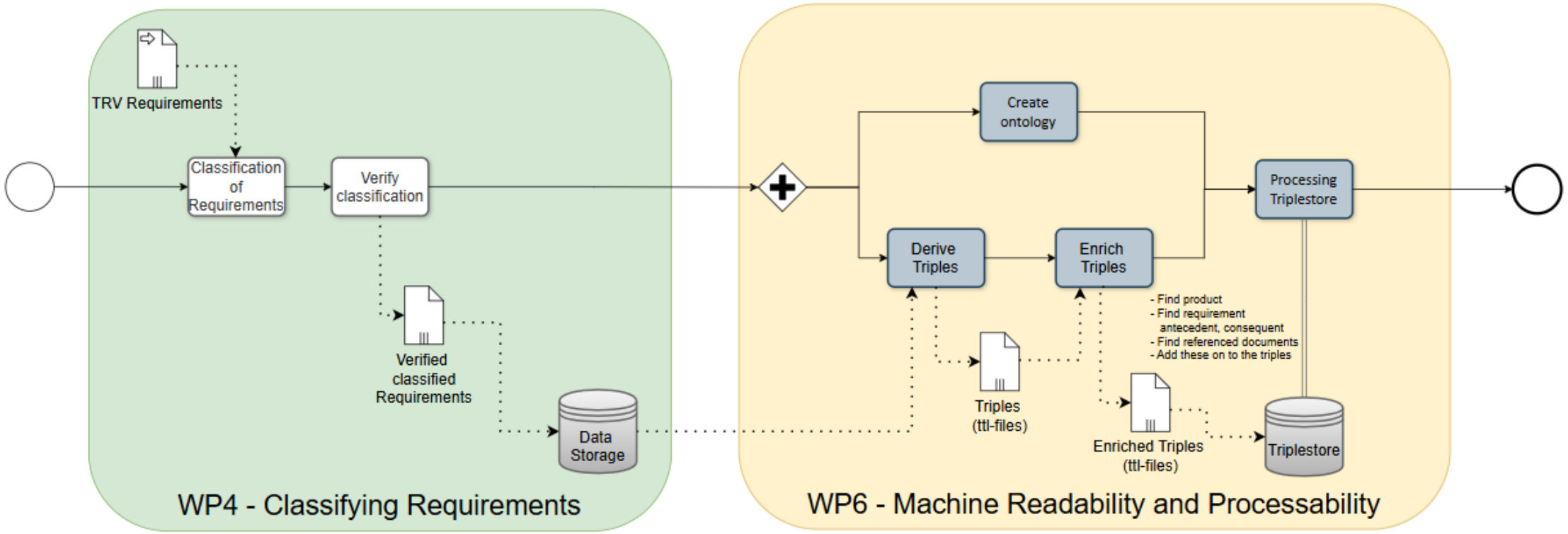


Work Package 7/8

Proof of Concept for Verification



WP6 – Transferring Requirements to Machine Readability



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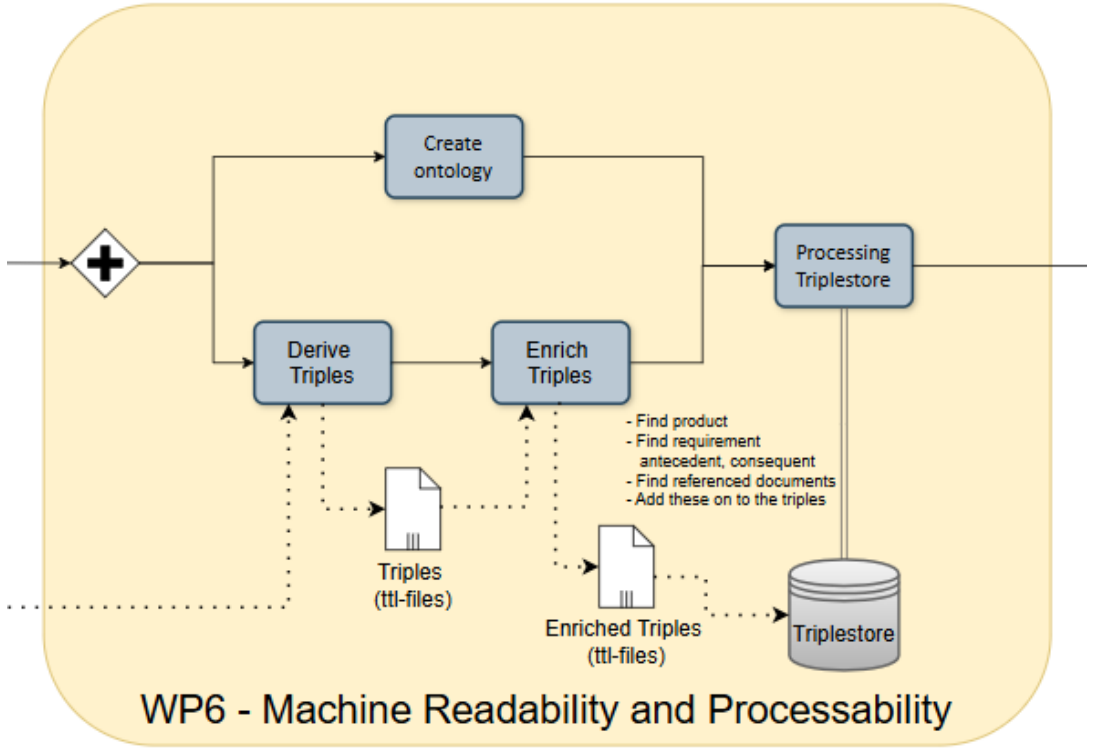


Requirements in Natural Language

formalize business vocabulary and rules

SBVR - Semantics of Business Vocabulary and Business Rules

Transferring Triples

WP7

Enabling Verification

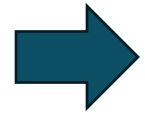
SPARQL – SPARQL Protocol and RDF Query Language

WP6 – SBVR Format

Term:	represents object types, concepts
Verb:	represents a verb/preposition/combination of both
Keyword:	used for linguistic symbols used to construct statements in combination with terms and verbs

Example:

"**Foundations** that **are not protected** by a **guardrail** or similar **shall be placed** **so that no part of** the **upper surface** of the **foundation** **is higher than 0.1 m above** the **finished ground**."



WP6 – SBVR Format

"Foundations that are not protected by a guardrail or similar shall be placed so that no part of the upper surface of the foundation is higher than 0.1 m above the finished ground."

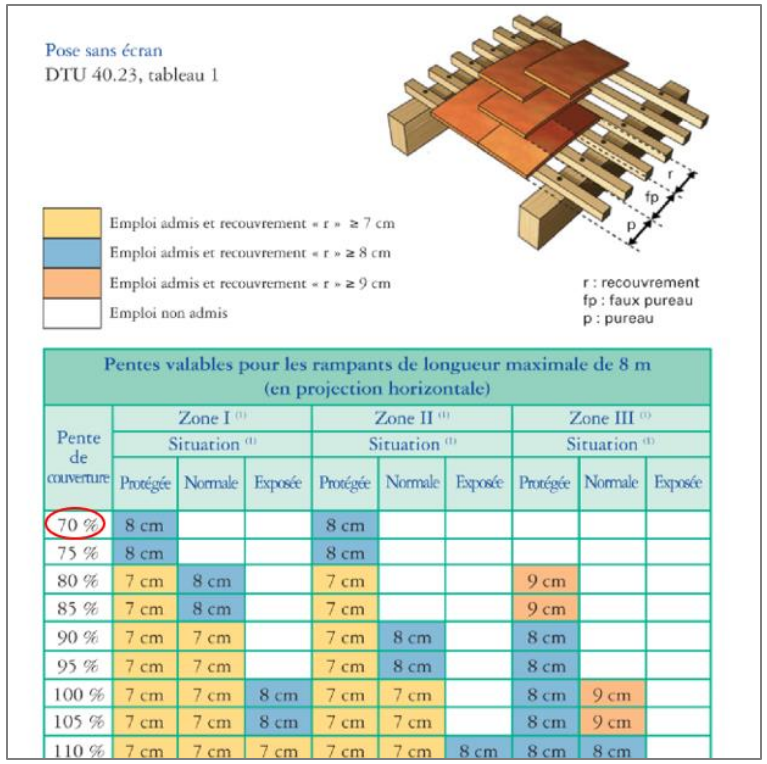
If-Then Formulations

Antecedent: *If a foundation is not protected by a guardrail or similar*
Then **Consequent:** *The foundation must be placed so that no part of the upper surface of the foundation is higher than 0.1 m above the finished ground.*

Better: **Multiple If-Then rules for clarity**

Antecedent: *If a foundation is not protected by a guardrail or similar*
Then **Consequent:** *The foundation must be placed.*
Antecedent: *If a foundation is placed*
Then **Consequent:** *No part of the upper surface of the foundation shall be higher than 0.1 m above the finished ground.*

WP6 – SBVR Format



Pose sans écran
DTU 40.23, tableau 1

Emploi admis et recouvrement « r » ≥ 7 cm
Emploi admis et recouvrement « r » ≥ 8 cm
Emploi admis et recouvrement « r » ≥ 9 cm
Emploi non admis

r : recouvrement
fp : faux pureau
p : pureau

Pentes valables pour les rampants de longueur maximale de 8 m (en projection horizontale)

Pente de couverture	Zone I (1) Situation (1)			Zone II (1) Situation (1)			Zone III (1) Situation (1)		
	Protégée	Normale	Exposée	Protégée	Normale	Exposée	Protégée	Normale	Exposée
70 %	8 cm			8 cm					
75 %	8 cm			8 cm					
80 %	7 cm	8 cm		7 cm			9 cm		
85 %	7 cm	8 cm		7 cm			9 cm		
90 %	7 cm	7 cm		7 cm	8 cm		8 cm		
95 %	7 cm	7 cm		7 cm	8 cm		8 cm		
100 %	7 cm	7 cm	8 cm	7 cm	7 cm		8 cm	9 cm	
105 %	7 cm	7 cm	8 cm	7 cm	7 cm		8 cm	9 cm	
110 %	7 cm	7 cm	7 cm	7 cm	7 cm	8 cm	8 cm	8 cm	

1. Transforming rows in textual constraints.

Example: „The pplicable tiles slope for a roof covering greater than 8cm , built in zone 1, in a protected situation is equal to 70%.“

2. Rewrite this text into SBVR rules and format:

If the tile *has* a slope equal to 70%
then it is obligatory that the implementation is in Zone 1,
in a protected situation with a roof covering greater than 8 cm.

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ISSN 1999-5903; www.mdpi.com/journal/futureinternet Article

WP6 – SBVR Format

Let us consider the following regulatory text:

The dimension of the main frame must be:

- Width: (847 ± 5) mm.
- Height :(1910 ± 5) mm.

"The maximum width of a main frame must be lower or equal to 853 mm and the minimum width higher or equal to 842mm. The maximum height of a main frame must be lower or equal to 1915 mm and the minimum height greater than or equal to 1905 mm".

If a frame *has* a minimum width higher or equal to 842mm and *has* a minimum height higher or equal to 1905mm and *has* a maximum width less than or equal to 853mm and *has* a maximum height less than or equal to 1915mm, then it is a main frame

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WP6 – SBVR Format to SPARQL

“Foundations that are not protected by a guardrail or similar shall be placed so that no part of the upper surface of the foundation is higher than 0.1 m above the finished ground.”

```
PREFIX dt:<http://www.semanticweb.org/DossierTechniqueProtegeV.owl#>
PREFIX xsd:<http://www.w3.org/2001/XMLSchema#>

ASK {
  ?foundation a dt:Foundation .
  OPTIONAL { ?foundation dt:hasProtection ?protection . }
  FILTER (!BOUND(?protection))
  ?foundation dt:hasUpperSurface ?upperSurface .
  ?upperSurface dt:heightFromGround ?height .
  FILTER (xsd:decimal(?height) <= 0.1)
}
```

```
PREFIX dt: <http://www.semanticweb.org/DossierTechniqueProtegeV.owl#>
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```
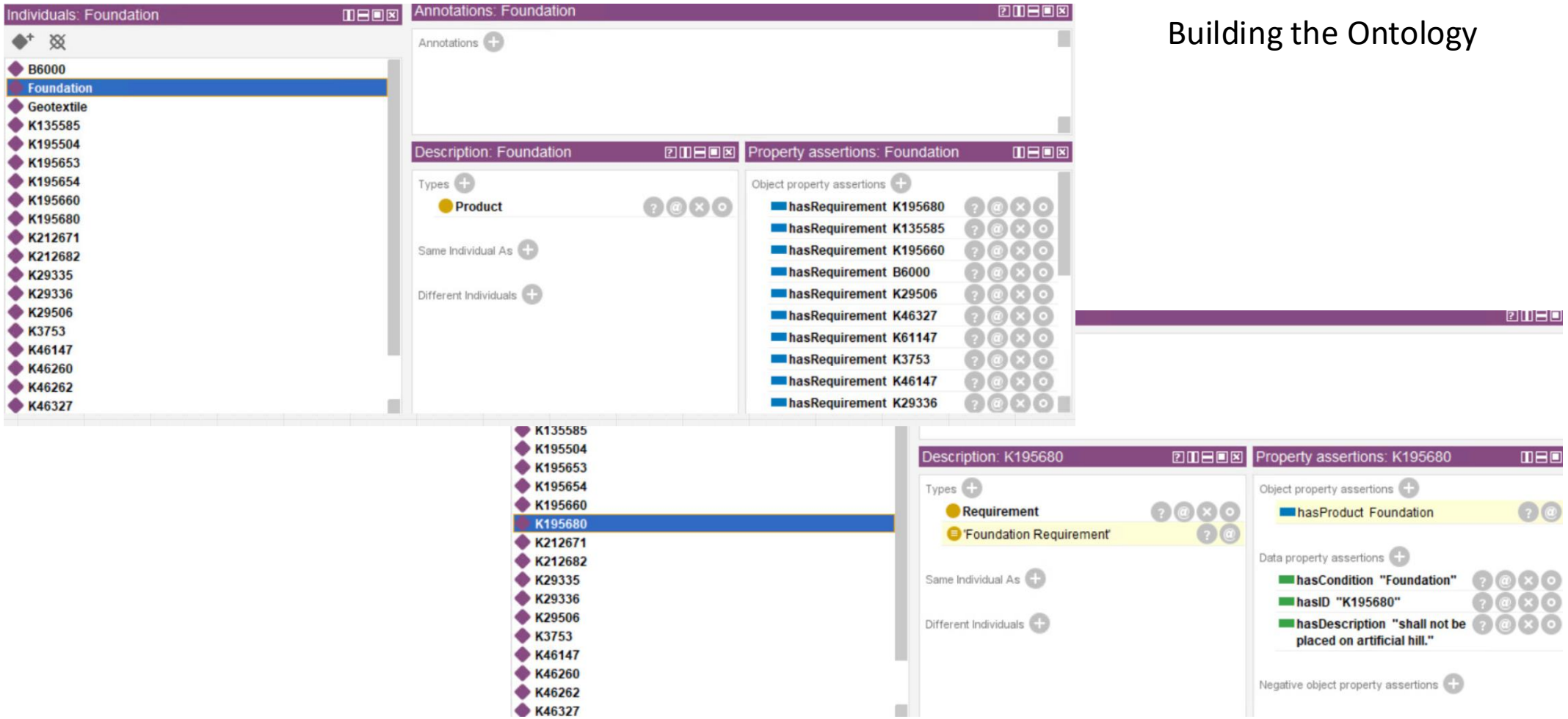
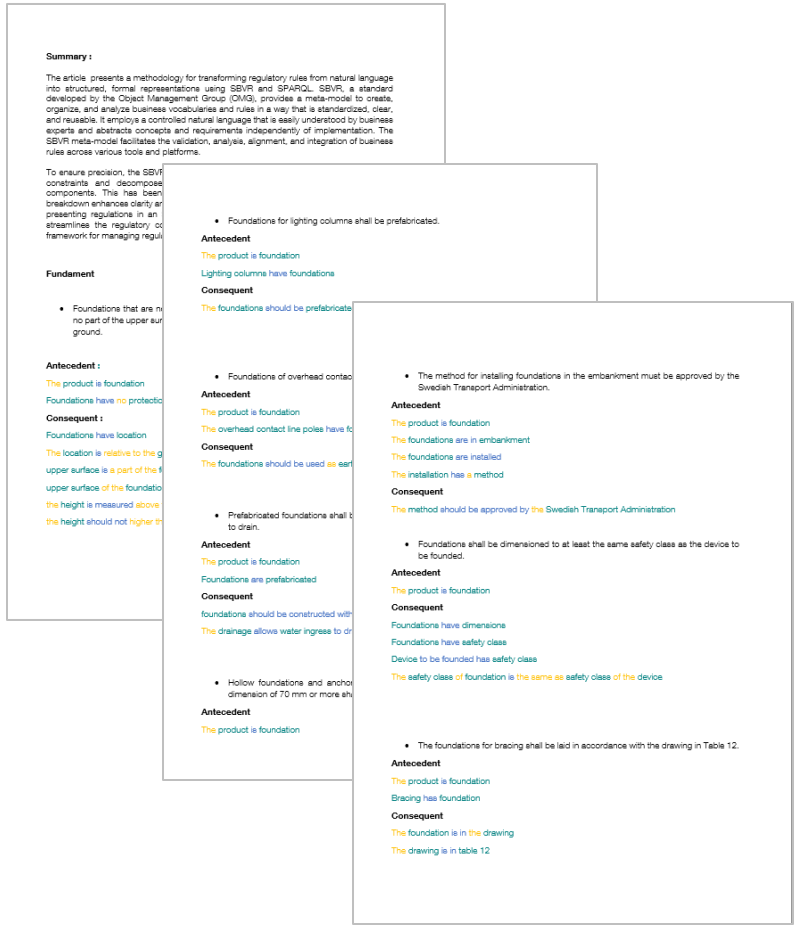

WP6 – SBVR Format – Current Status



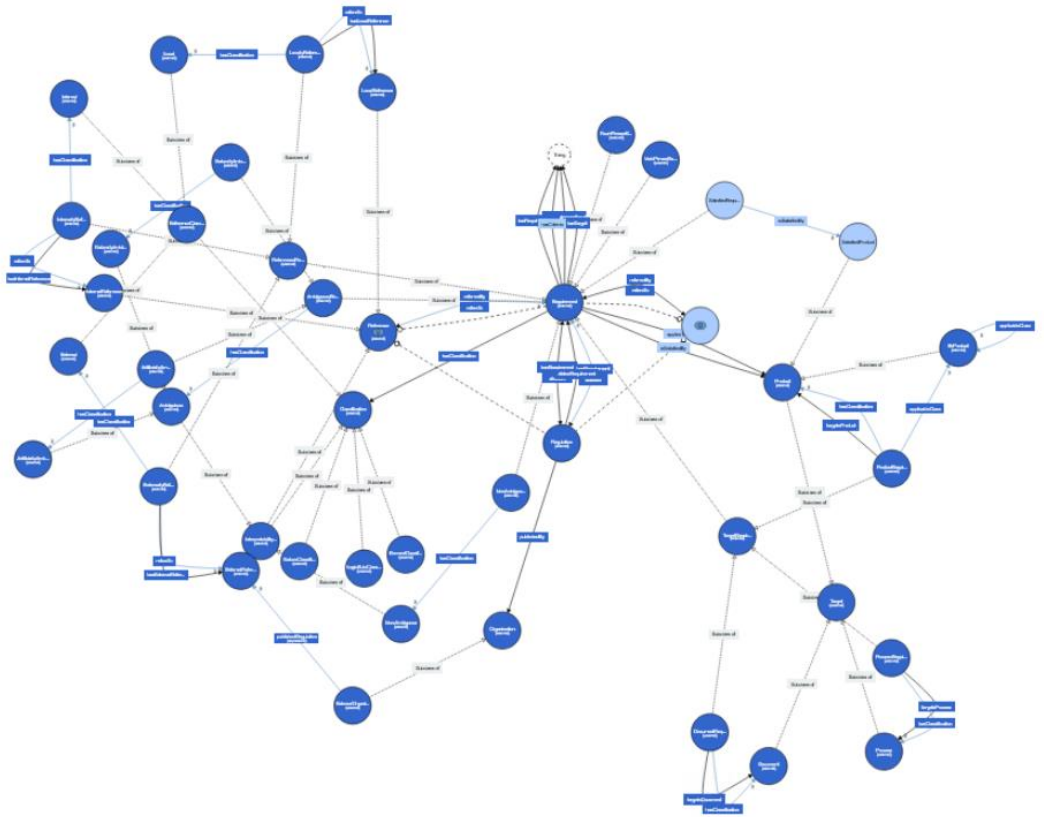
Building the Ontology

WP6 – SBVR Format – Current Status



Approx. 70 requirements

- Foundations
- Handrails
- Railings



Objective 3

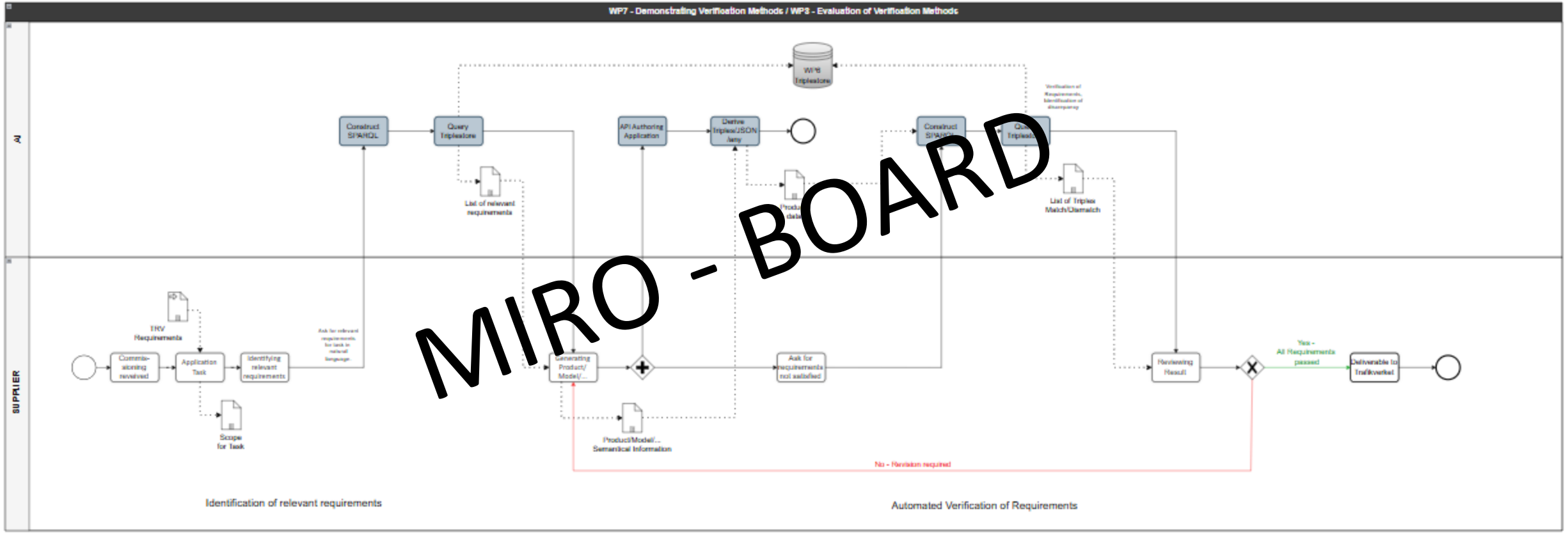
Develop procedures for automated, reusable, verification of requirements

Work Package 07 – Demonstration of verification methods of models

Work Package 08 – Evaluation of verification methods

Work Package 09 – Roadmap and recommendations for implementation

WP7 – Demonstration of verification methods of models - Process



WP7 – Relevant Requirements

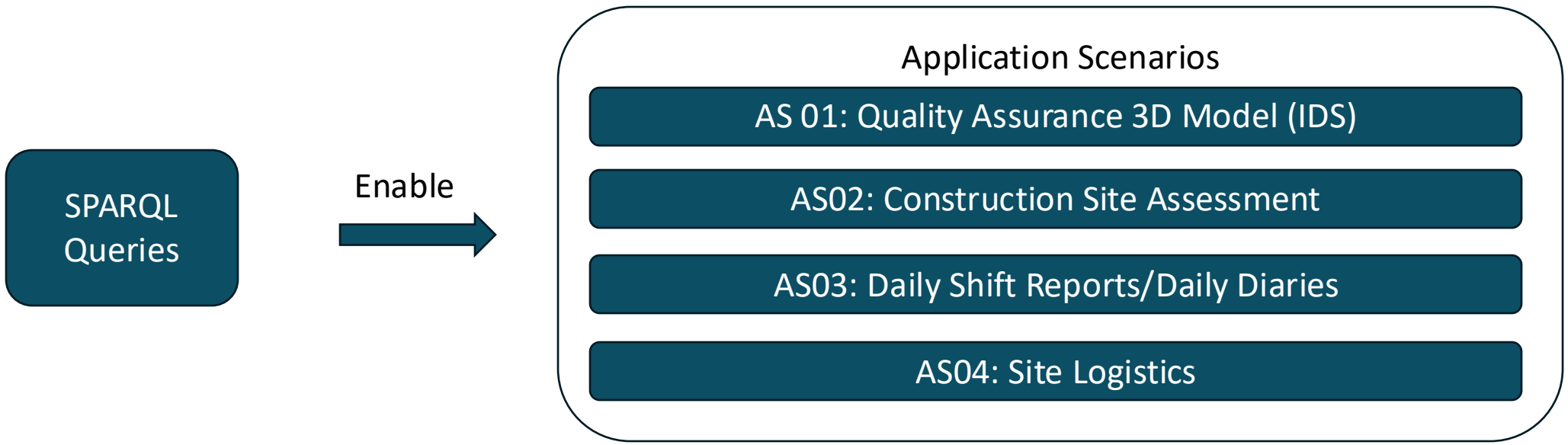
Run | Show Plan | Reasoning | svar-requirements | Save to File | Store Query

```
1  PREFIX svar: <http://www.viconbim.com/svar/>
2  PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
3
4  SELECT ?id ?description
5  WHERE {
6      ?product rdf:type svar:Product .
7      ?product svar:hasType "Foundations" .
8      ?product svar:hasRequirement ?requirement .
9      ?requirement svar:hasID ?id .
10     ?requirement svar:hasDescription ?description .
11 }
```

Run to File | Text | Charts | Visualize | 18 Results, 354 ms

id	description
"B6000"	"reinforced foundations shall be carried out in accordance with Section 12."
"K135585"	"the difference in vertical pressure under the bridge and the connecting bank shall be taken into account."
"K195504"	"the foundation shall be adapted to the conditions on site."
"K195653"	"shall be dimensioned and installed so that any loads can be transferred with sufficient safety to the ground and surrounding fill and s...
"K195654"	"shall be dimensioned in at least the same safety class as the device to be founded."
"K195660"	"shall be dimensioned to take loads according to section 8."
"K195680"	"shall not be placed on artificial hill."
"K212671"	"shall be permanently marked with year of manufacture and supplier."
"K212682"	"shall be constructed so that luminaires are aligned in relation to current lighting calculations."
"K29335"	"shall meet EBE requirements."
"K29336"	"shall meet the requirements of DEG."
"K29506"	"shall not be poured during frost."
"K3753"	"shall be at least 700 mm high."
"K46147"	"shall be approved by the Swedish Transport Administration."
"K46327"	"shall be made of concrete."
"K46332"	"shall be beveled."
"K57213"	"shall be larger than the outer dimension of the transformer to withstand an oil leakage from the flange."
"K61147"	"shall be designed in accordance with TRVINFRA-00136 Electric power installation Overhead contact line Foundations and strut ancho...

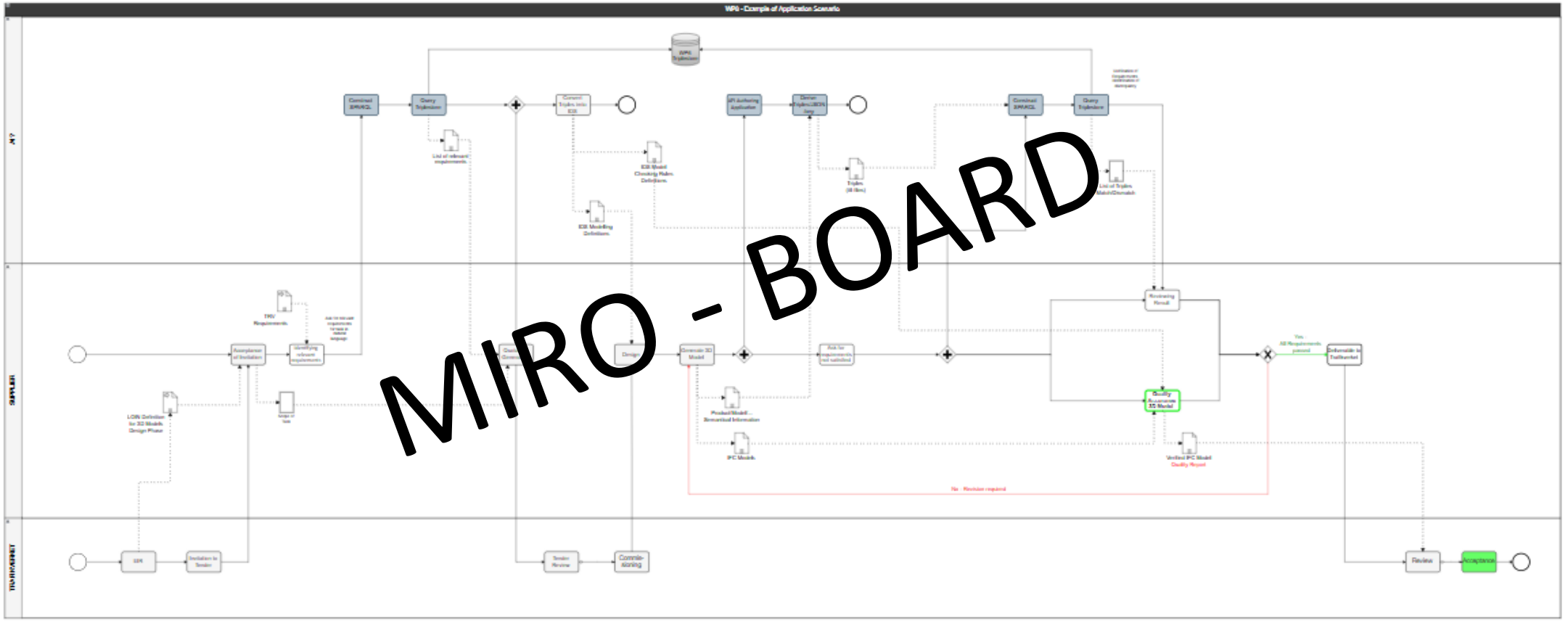
WP8 – verification methods



AI Search: Establishing different workspaces for stakeholders, Indexing of relevant documents

Manual Checks

WP8 – Application Scenarios



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

~

Reporting of Evaluation
- Findings
- Limitations
- Challenges

~

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?

Synergies with other projects

- Done:
  - Förstudie: Intelligent lösning för kvalitetssäkrad livscykelhantering av krav (Jesper Kornestedt).

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

IVA-100 list

- Research2Business event on Feb 6, Stockholm
- Participants from Trafikverket
  - Susanne Skovgaard (Chef Strategisk Utveckling)
  - Olof Johansson (Programchef Digitaliserat Transportsystem)

Next steps

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

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