

# 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



# 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 initiatives

**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?

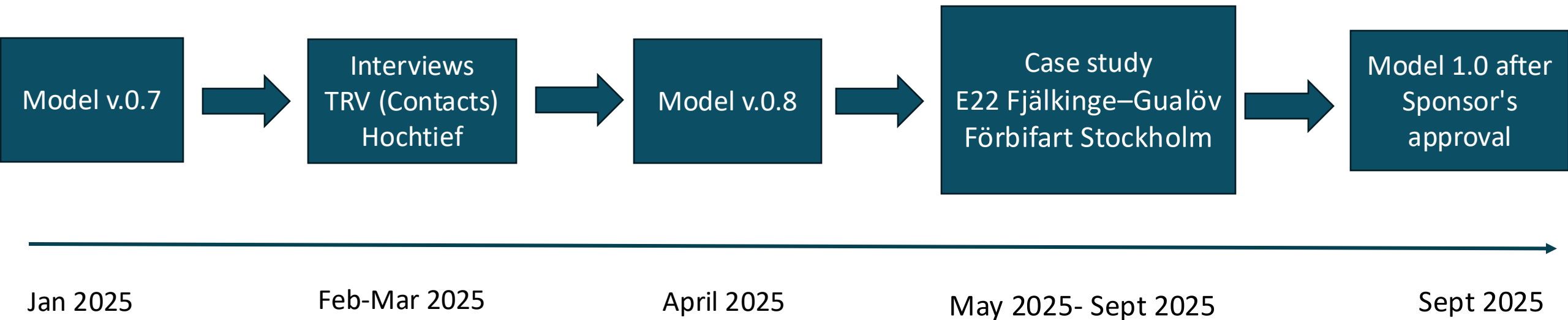
Level 4: Scaling up

Level 3: Semantic models, updates

Level 2: Compliance checking rules development

Level 1: Finding regulations, data extraction, process identification

# ACC CMM Model Evaluation





# Objective 2: TRV Infra 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**

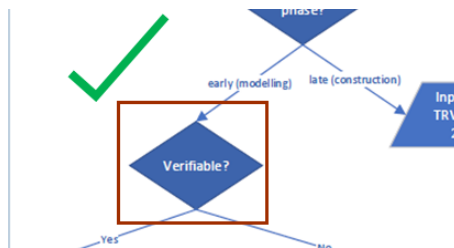
**Objective 3: Demonstration of verification methods**

# Work Package 6

## Current Approach / Activities

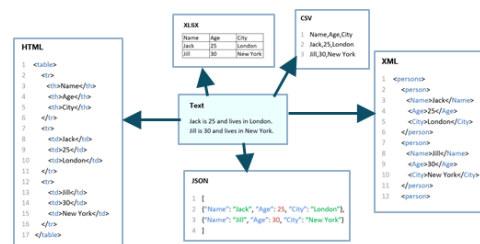
Work Packages 4/5  
(Input)

List of verifiable  
Requirements



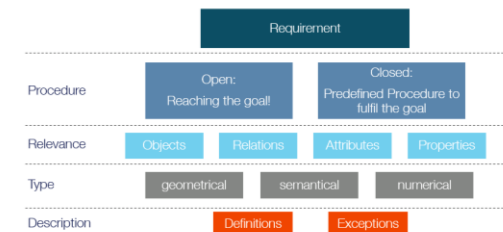
Work Package 6

Methods to make  
Requirements machine  
readable



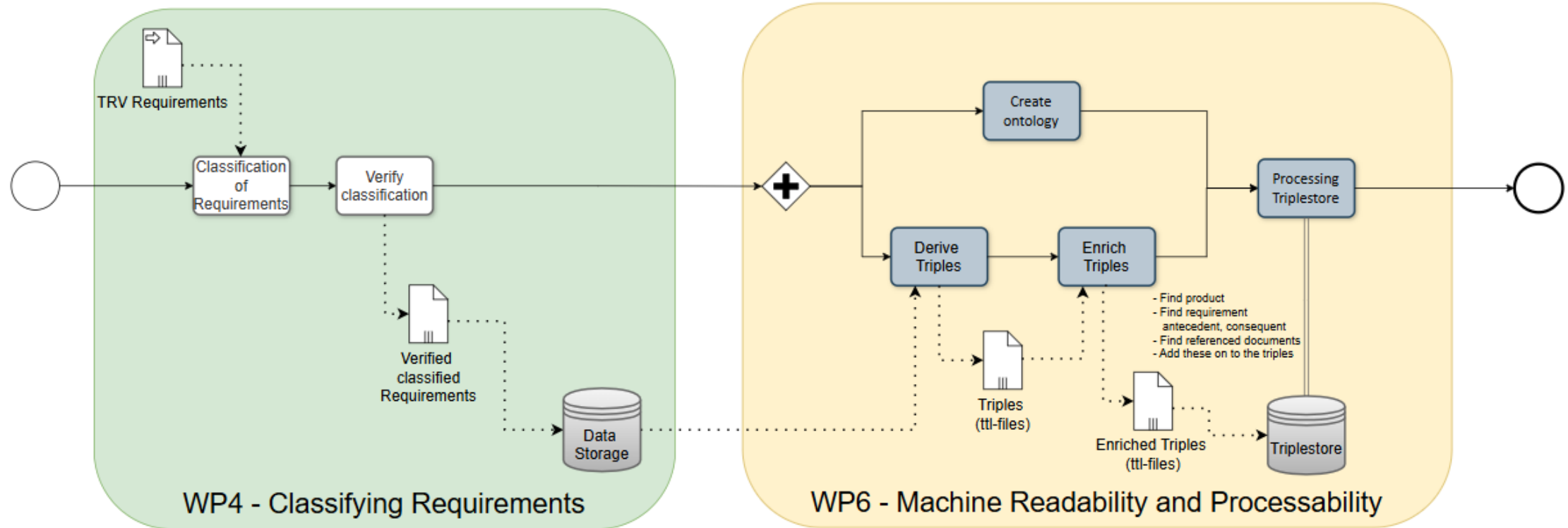
Work Package 7/8

Proof of Concept for  
Verification

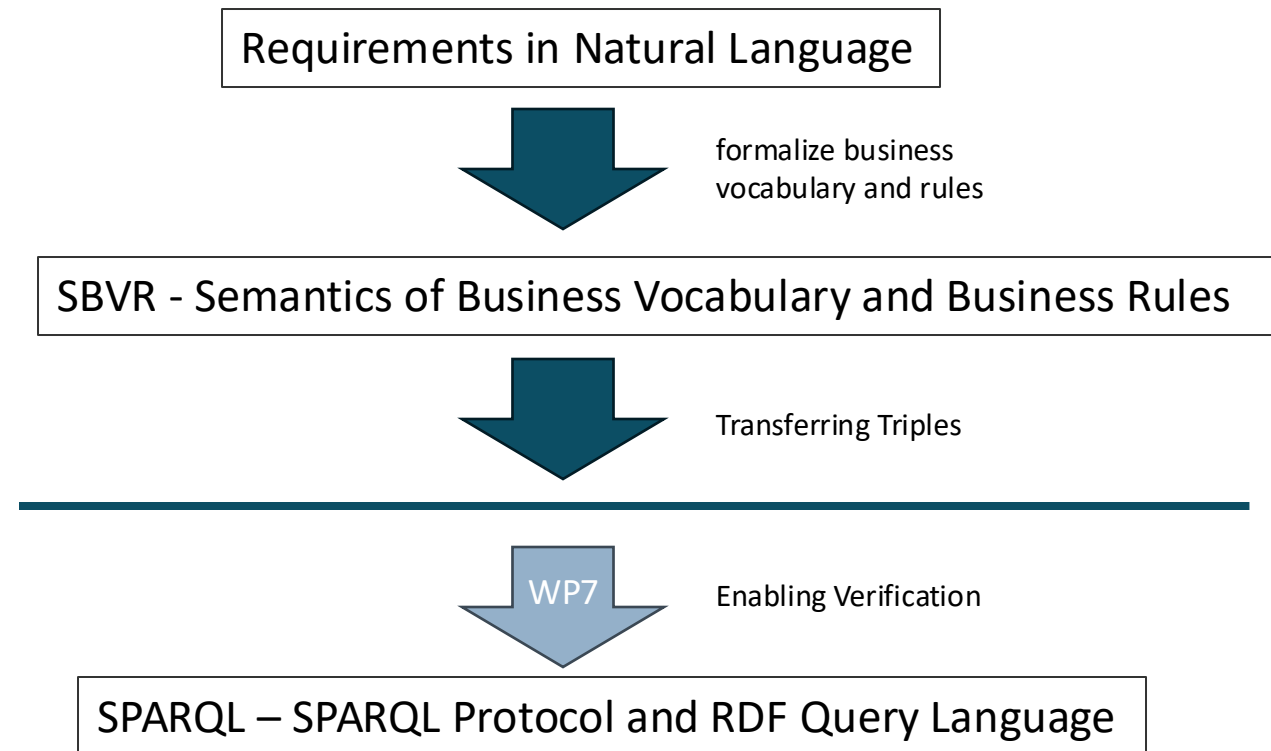
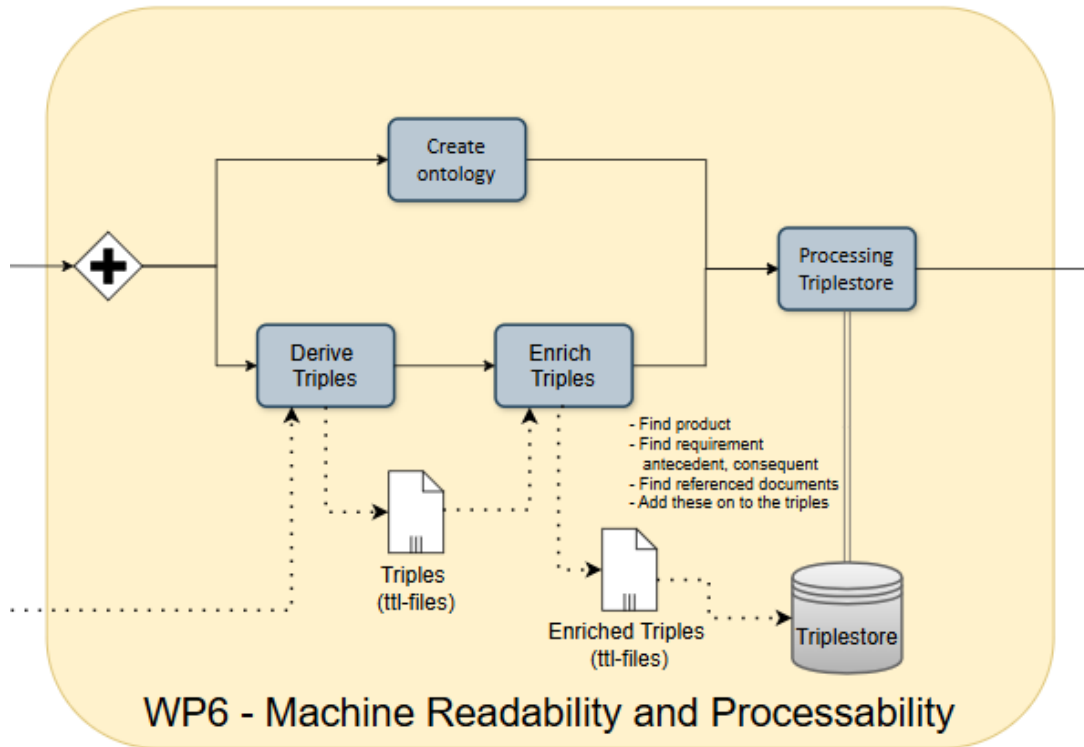




# WP6 – Transferring Requirements to Machine Readability



# WP6 – Transferring Requirements to Machine Readability



# 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.*

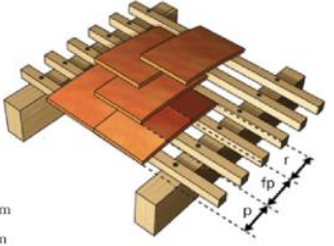
## Better: Multiple If-Then rules for clarity

**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.*

*If... Then...  
If... Then...  
If... Then...  
If... Then...*

# 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 <sup>(1)</sup>			Zone II <sup>(1)</sup>			Zone III <sup>(1)</sup>		
	Situation <sup>(1)</sup>			Situation <sup>(1)</sup>			Situation <sup>(1)</sup>		
	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 applicable 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.**

# WP6 – SBVR Format

Let us consider the following regulatory text:

The dimension of the main frame must be:

- Width:  $(847 \pm 5)$  mm.
- Height :  $(1910 \pm 5)$  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**

# 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#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>

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

# WP6 – SBVR Format – Current Status

Building the Ontology

The screenshot displays an ontology editor interface with two main panels. The top-left panel, titled 'Individuals: Foundation', shows a list of individuals: B6000, Foundation (highlighted), Geotextile, K135585, K195504, K195653, K195654, K195660, K195680, K212671, K212682, K29335, K29336, K29506, K3753, K46147, K46260, K46262, and K46327. The top-right panel, titled 'Annotations: Foundation', is currently empty. The bottom-left panel, titled 'Description: Foundation', shows the type 'Product' and options for 'Same Individual As' and 'Different Individuals'. The bottom-right panel, titled 'Property assertions: Foundation', lists several 'hasRequirement' assertions for various individuals: K195680, K135585, K195660, B6000, K29506, K46327, K61147, K3753, K46147, and K29336. A second set of panels is shown below, detailing the 'Foundation' individual. The 'Description: K195680' panel shows types 'Requirement' and 'Foundation Requirement'. The 'Property assertions: K195680' panel shows object property assertions: 'hasProduct Foundation', and data property assertions: 'hasCondition "Foundation"', 'hasID "K195680"', and 'hasDescription "shall not be placed on artificial hill."'.



# WP6 – SBVR Format – Current Status

Approx. 70 requirements

- Foundations
- Handrails
- Railings

**Summary :**  
 The article presents a methodology for transforming regulatory rules from natural language into structured, formal representations using SBVR and SPARQL. SBVR, a standard developed by the Object Management Group (OMG), provides a meta-model to create, organize, and analyze business vocabularies and rules in a way that is standardized, clear, and reusable. It employs a controlled natural language that is easily understood by business experts and abstracts concepts and requirements independently of implementation. The SBVR meta-model facilitates the validation, analysis, alignment, and integration of business rules across various tools and platforms.

To ensure precision, the SBVR constraints and decompose components. This has been broken down into clear and presenting regulations in an examines the regulatory framework for managing regul

**Fundament**

- Foundations that are in no part of the upper sur ground.

**Antecedent :**  
 The product is foundation  
 Foundations have no protect

**Consequent :**  
 Foundations have location  
 The location is relative to the upper surface is a part of the upper surface of the foundation  
 the height is measured above the height should not higher th

- Foundations for lighting column shall be prefabricated.

**Antecedent**  
 The product is foundation  
 Lighting column have foundation

**Consequent**  
 The foundations should be prefabricated

- Foundations of overhead contact

**Antecedent**  
 The product is foundation  
 The foundations are in embankment

**Consequent**  
 The foundations should be used as ear

- Prefabricated foundations shall to drain.

**Antecedent**  
 The product is foundation  
 Foundations are prefabricated

**Consequent**  
 foundations should be constructed with  
 The drainage allows water ingre to dr

- Hollow foundations and ancho dimension of 70 mm or more sh

**Antecedent**  
 The product is foundation

- The method for installing foundations in the embankment must be approved by the Swedish Transport Administration.

**Antecedent**  
 The product is foundation  
 The foundations are in embankment  
 The foundations are installed  
 The installation has a method

**Consequent**  
 The method should be approved by the Swedish Transport Administration

- Foundations shall be dimensioned to at least the same safety class as the device to be founded.

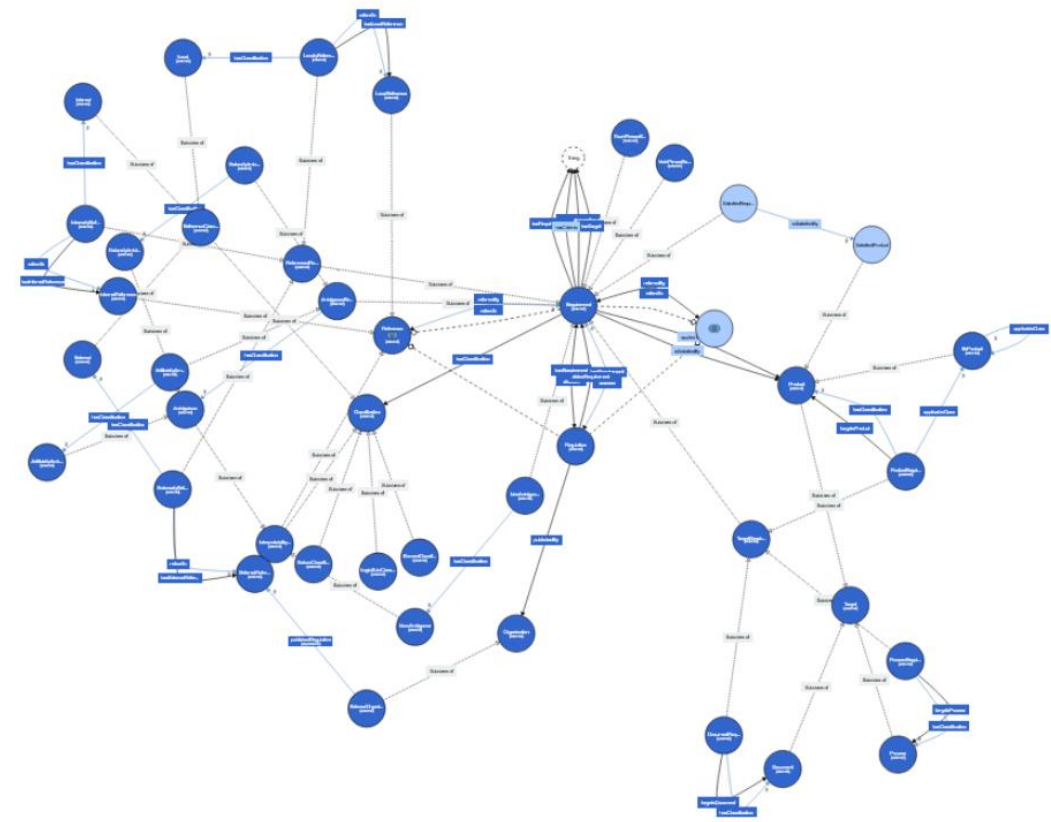
**Antecedent**  
 The product is foundation

**Consequent**  
 Foundations have dimensions  
 Foundations have safety class  
 Device to be founded has safety class  
 The safety class of foundation is the same as safety class of the device

- The foundations for bracing shall be laid in accordance with the drawing in Table 12.

**Antecedent**  
 The product is foundation  
 Bracing has foundation

**Consequent**  
 The foundation is in the drawing  
 The drawing is in table 12



# Objective 3

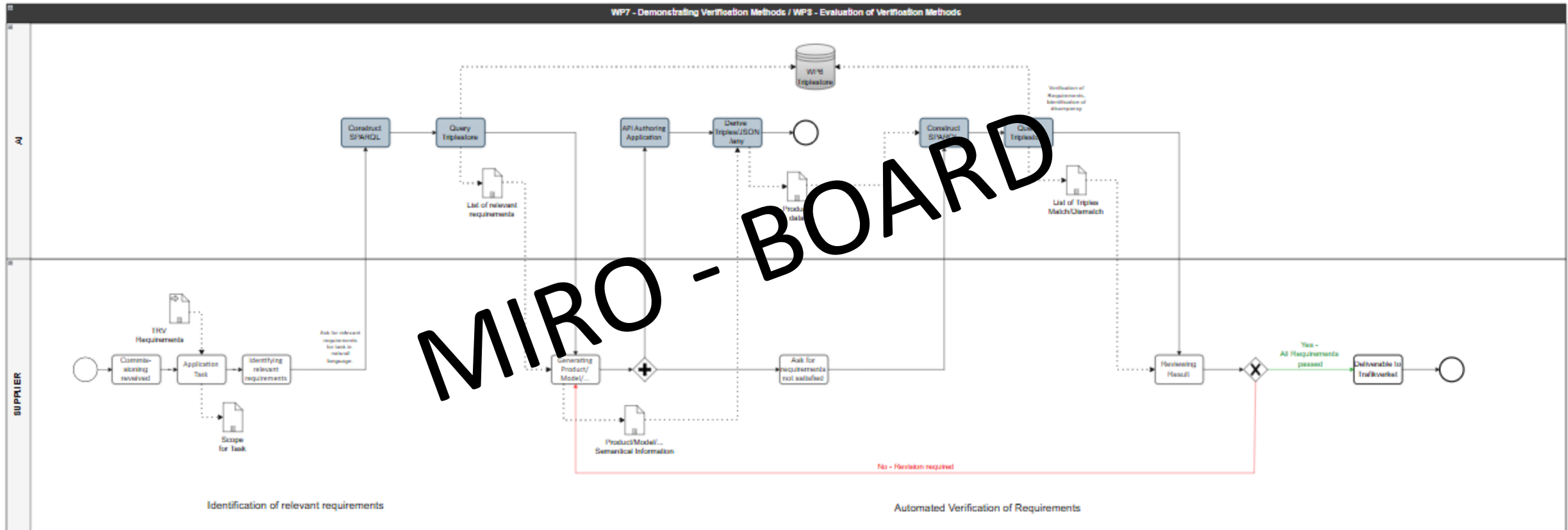
## Develop procedures for automated, reusable, verification of requirements

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



I

# 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...

Voicebox

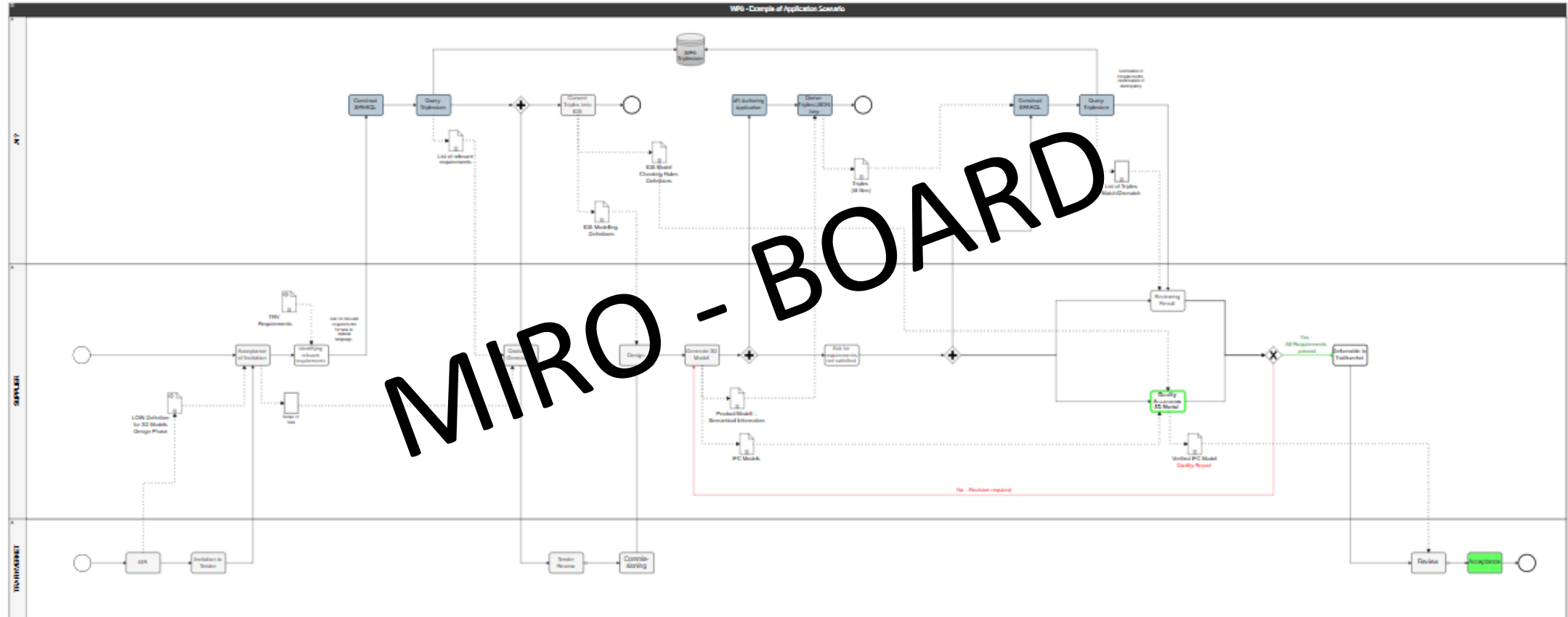
# WP8 – verification methods



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

