Detecting Contradictory Beliefs About Complex Systems Using Ontologies

project model driven engineering

By
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   What's an ontology again?

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1. Introduction

Train Control System (1)

European Train Control System (ETCS)

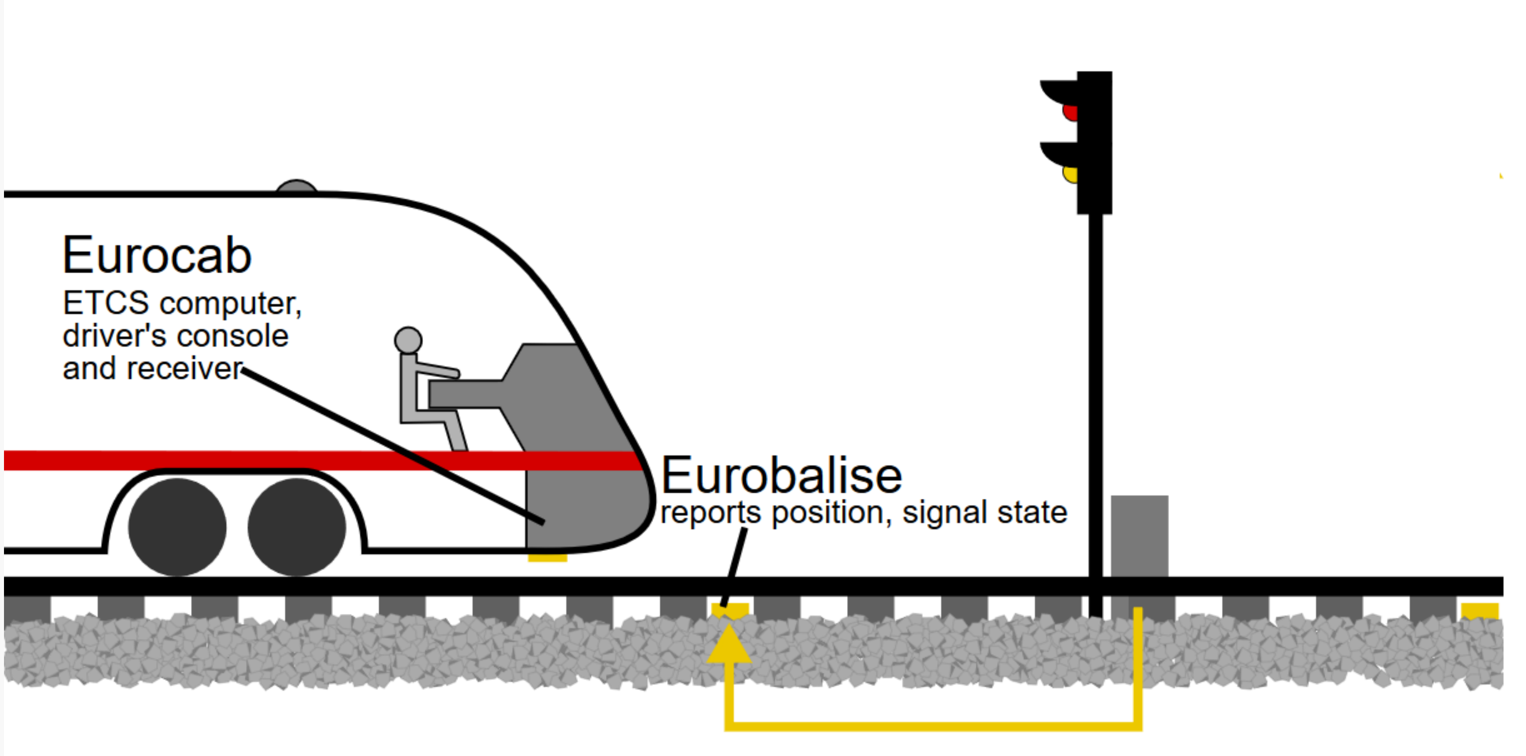


image adapted from https://en.wikipedia.org/wiki/European_Train_Control_System

Train Control System (2)

A balise or contact transmits position and signal information

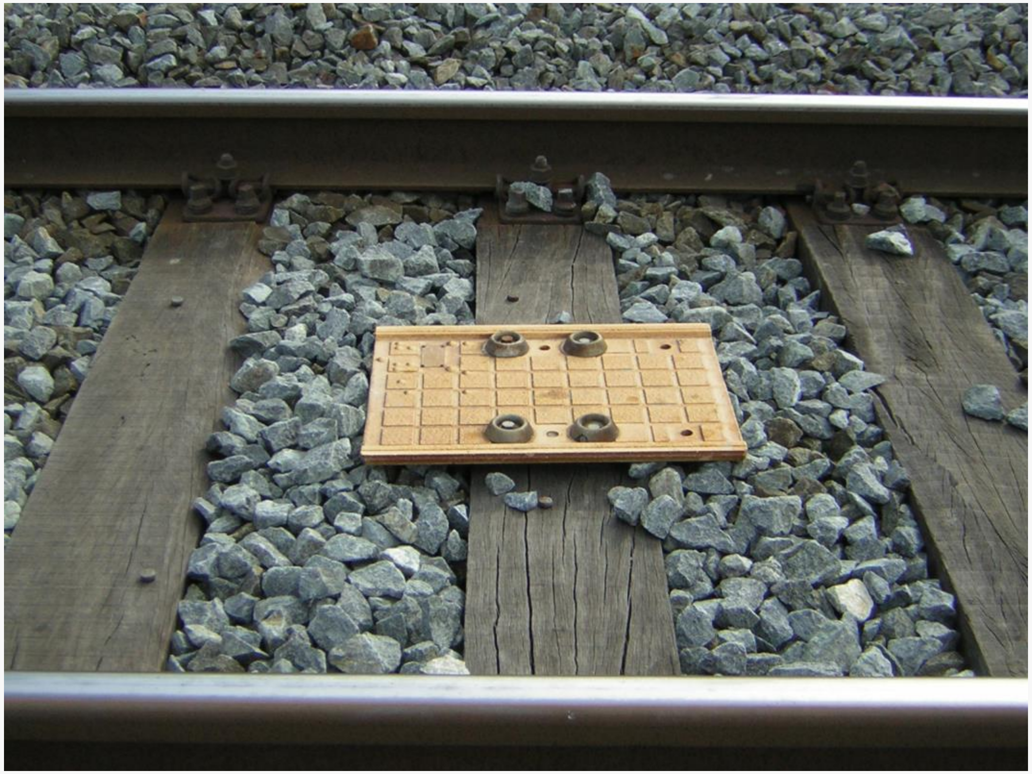


image from https://en.wikipedia.org/wiki/European_Train_Control_System

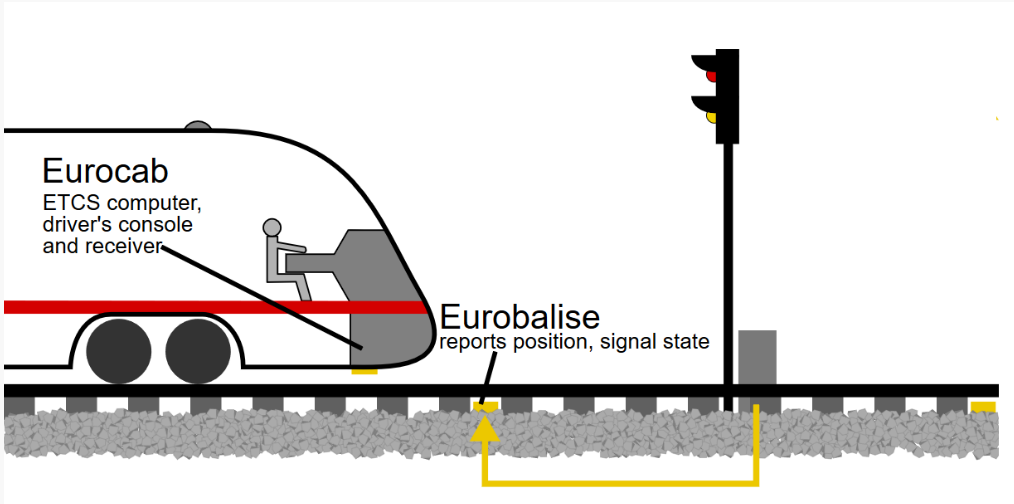
Train Control System (3)

The Crocodile, still used in Belgium

image from https://en.wikipedia.org/wiki/Crocodile_(train_protection_system)

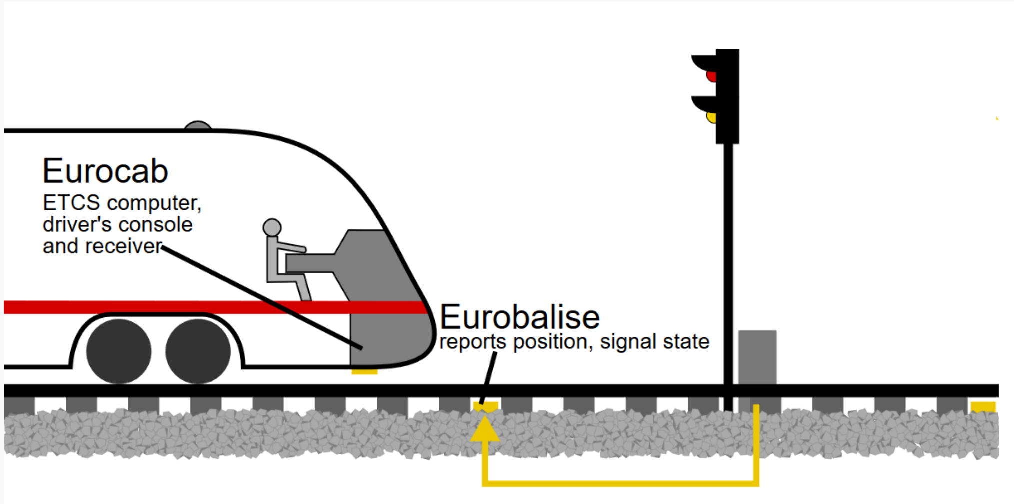
Some Requirements

- When a balise is passed, position and signal information is transmitted to the train.



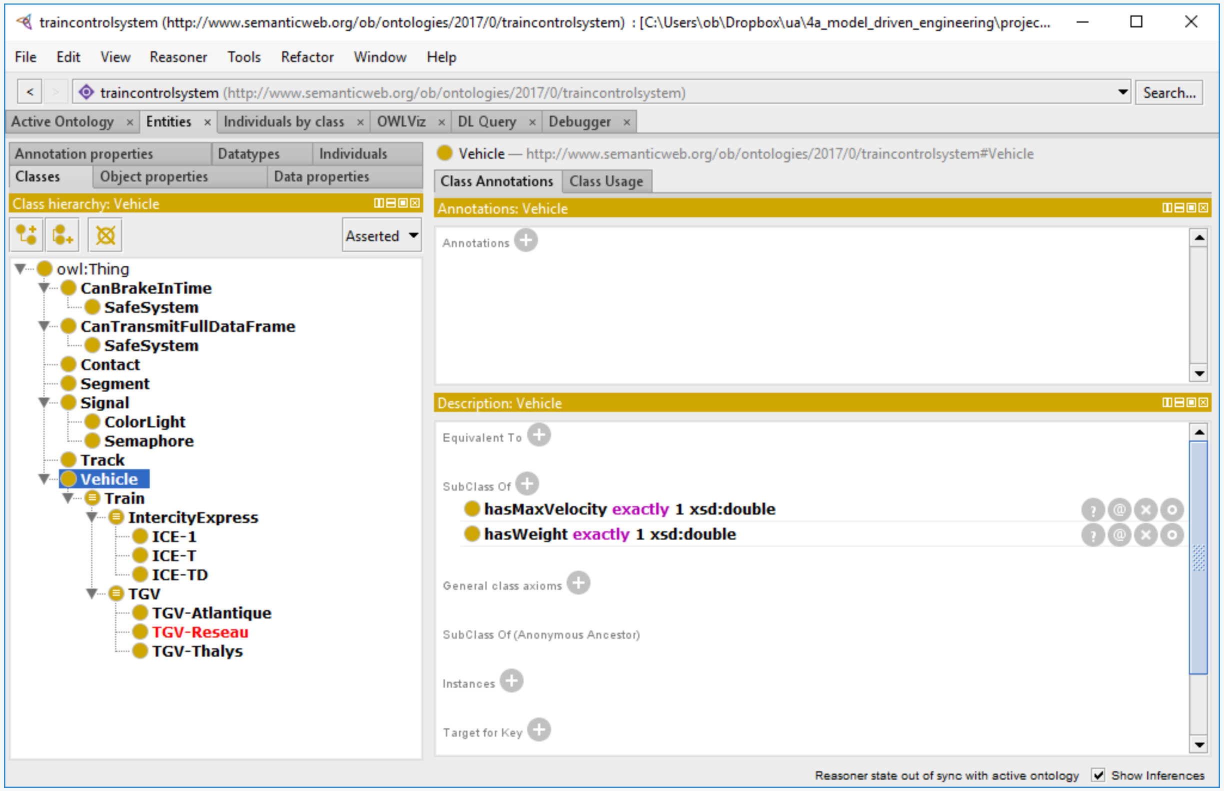
Some Requirements

- When a balise is passed, position and signal information is transmitted to the train.
- Passing a yellow light triggers a warning. Driver must acknowledge warning, or train is stopped.



Tool Used

Open-source ontology editor protégé



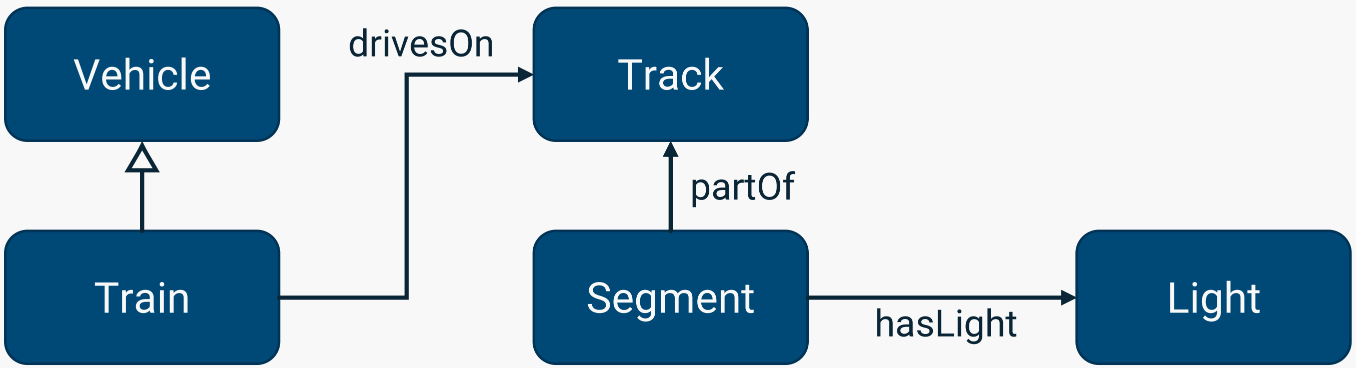
http://protege.stanford.edu/

2. Ontology Recap

Definition

- An ontology is a model of a particular domain
  - Concepts/Classes
  - Relations
- Serves a purpose
  - Shared understanding
  - **Automated reasoning**
  - Interoperability

Example


Vehicle
drivesOn
Track
partOf
Train
Segment
Light
hasLight

Ontology Languages (1)

"A train is a vehicle"

- Predicate Logic

  $\forall x[Train(x) \rightarrow Vehicle(x)]$

- Description Logic

  $Train \sqsubseteq Vehicle$

- OWL Web Ontology Language

  XML-based, Description Logic semantics

Ontology Languages (2)

- Concept constructors: $\sqcup, \sqcap, \neg, \forall r.C, \exists r.C, \geq_n r.C$ (common ones)
- Concept axioms: $\sqsubseteq, \equiv$

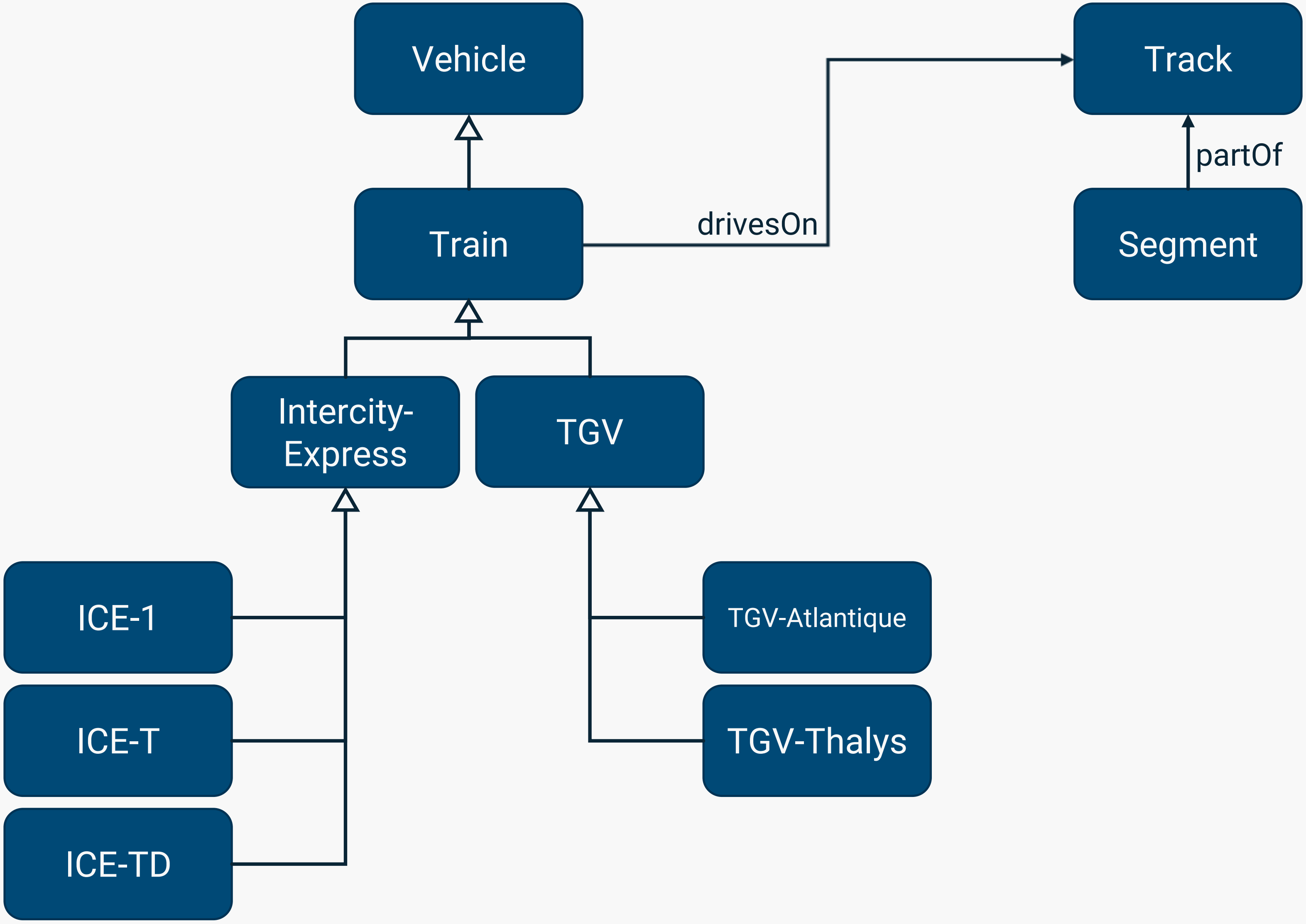
Ontology Languages (2)

- Concept constructors: $\sqcup, \sqcap, \neg, \forall r.C, \exists r.C, \geq_n r.C$ (common ones)
- Concept axioms: $\sqsubseteq, \equiv$
- Example:

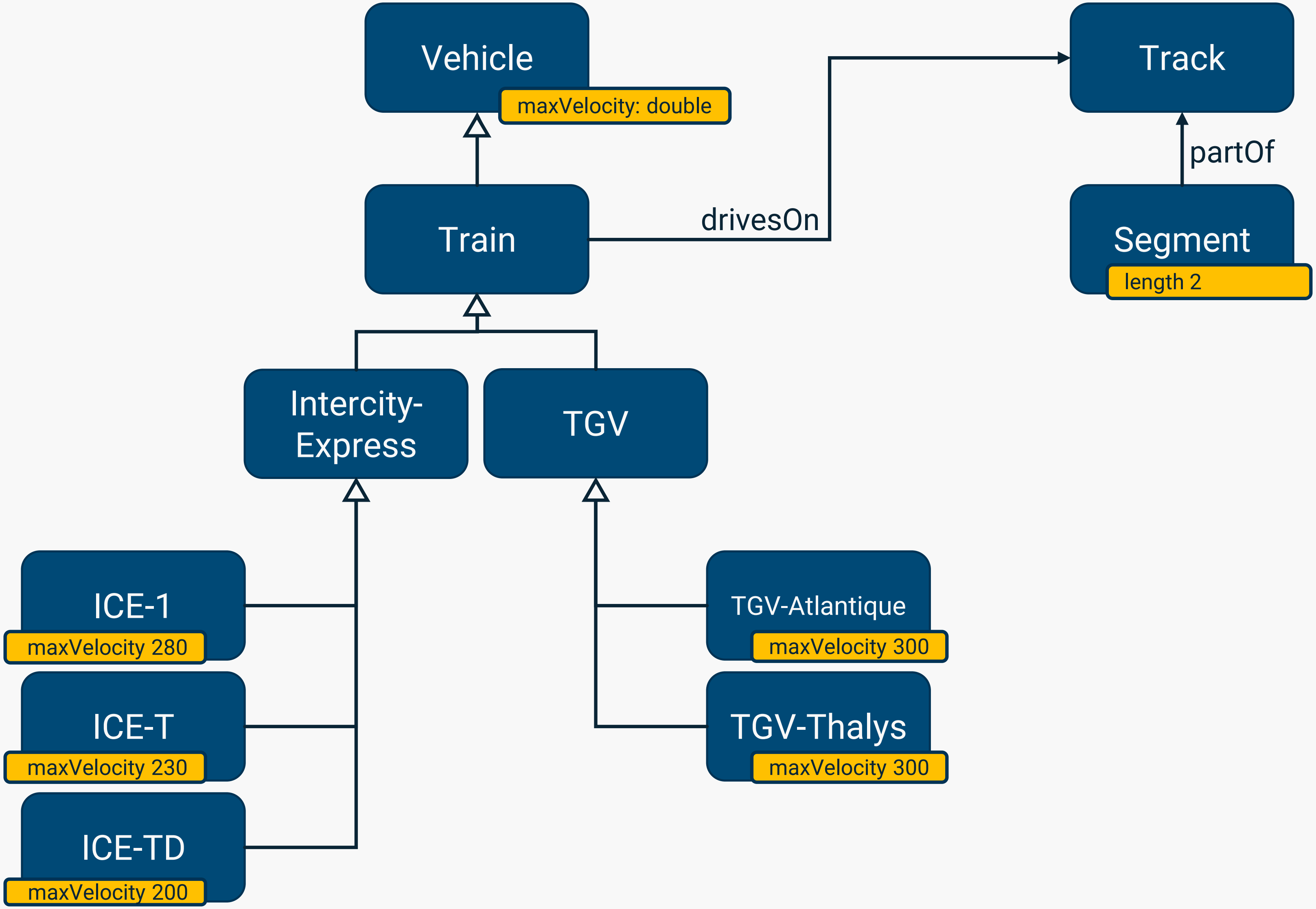
$$Vehicle \sqcap \leq_2 hasPart.Wheel$$

3. Train Control System Ontology

System Ontology



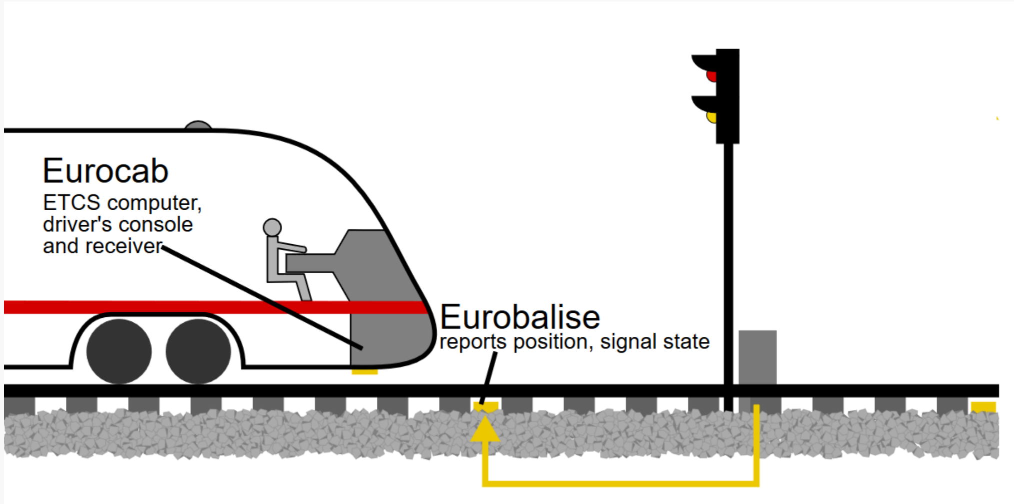
System Ontology



4. Detecting Inconsistencies

Requirement

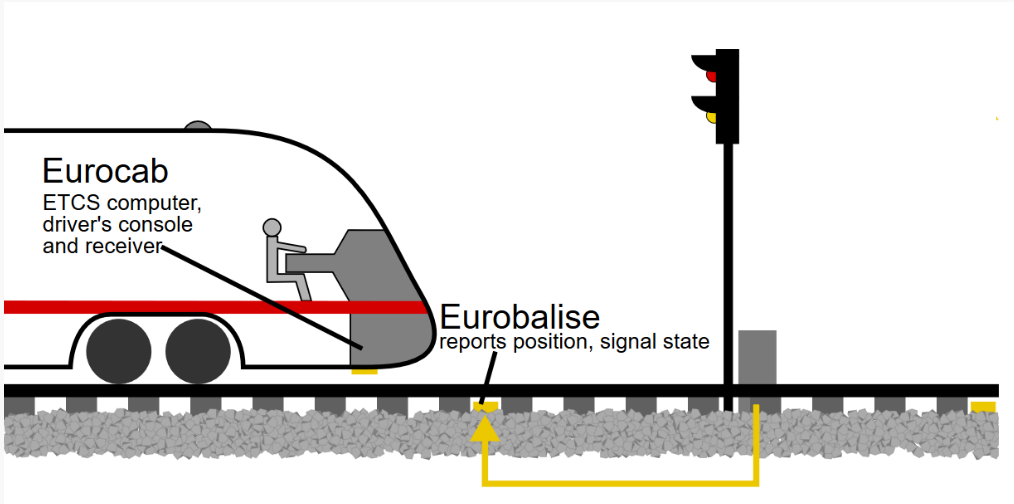
Requirement. Passing a yellow light triggers a warning. Driver must acknowledge warning, or train is stopped.



Requirement

Requirement. Passing a yellow light triggers a warning. Driver must acknowledge warning, or train is stopped.

Question. Can the train stop in time to prevent a collision?



Verifying Properties

- Assumptions
  - Train's velocity is at most 300km/h
  - Track segments are at least 2km in length

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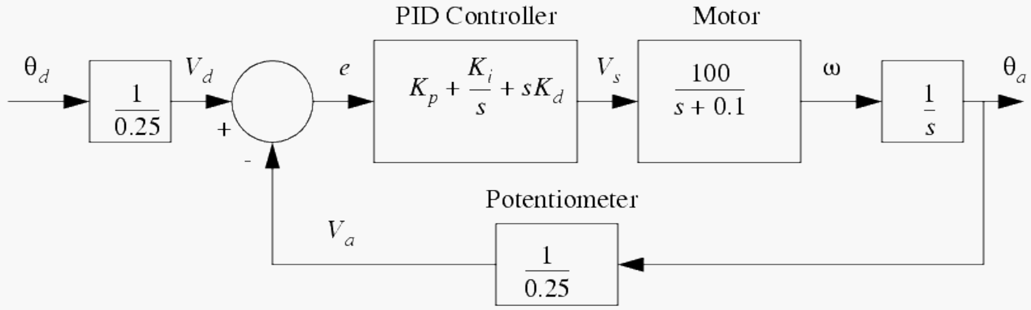

Verifying Properties

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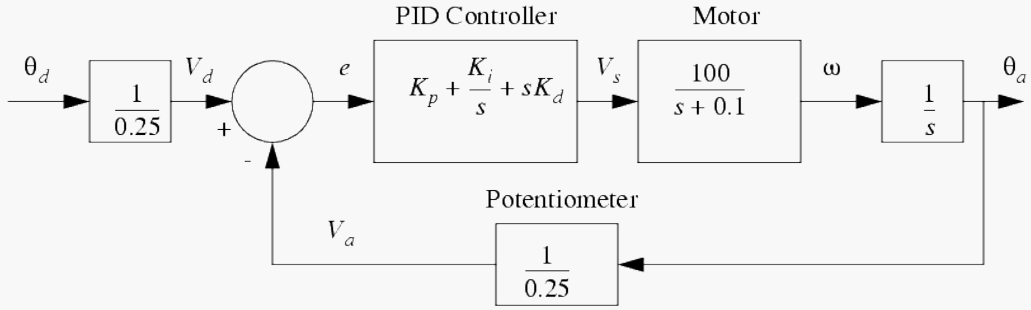
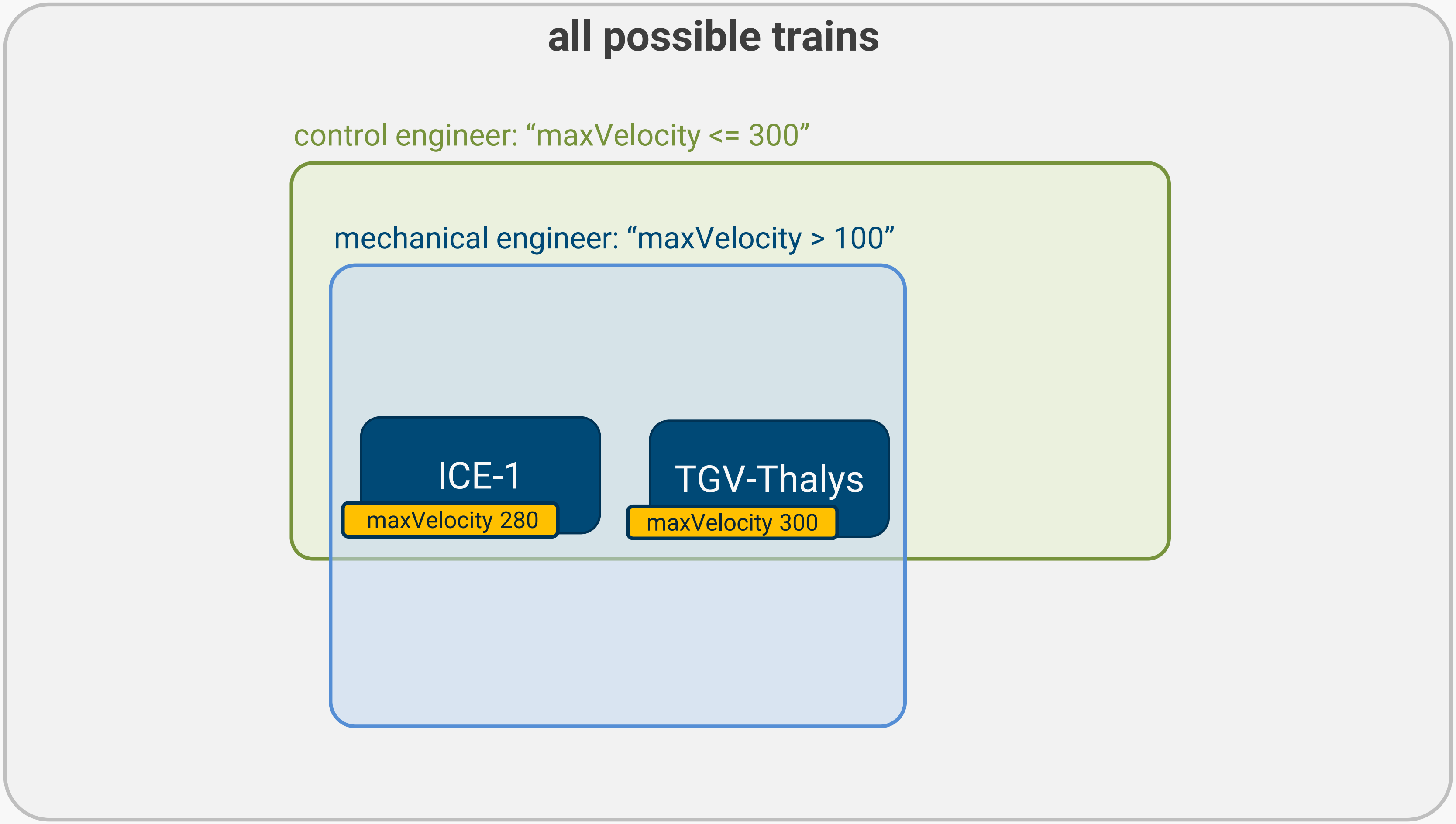


- Conclusions
  - Braking distance is 1.92km. The train can brake in time to prevent collisions.

Constraining Entities (1)



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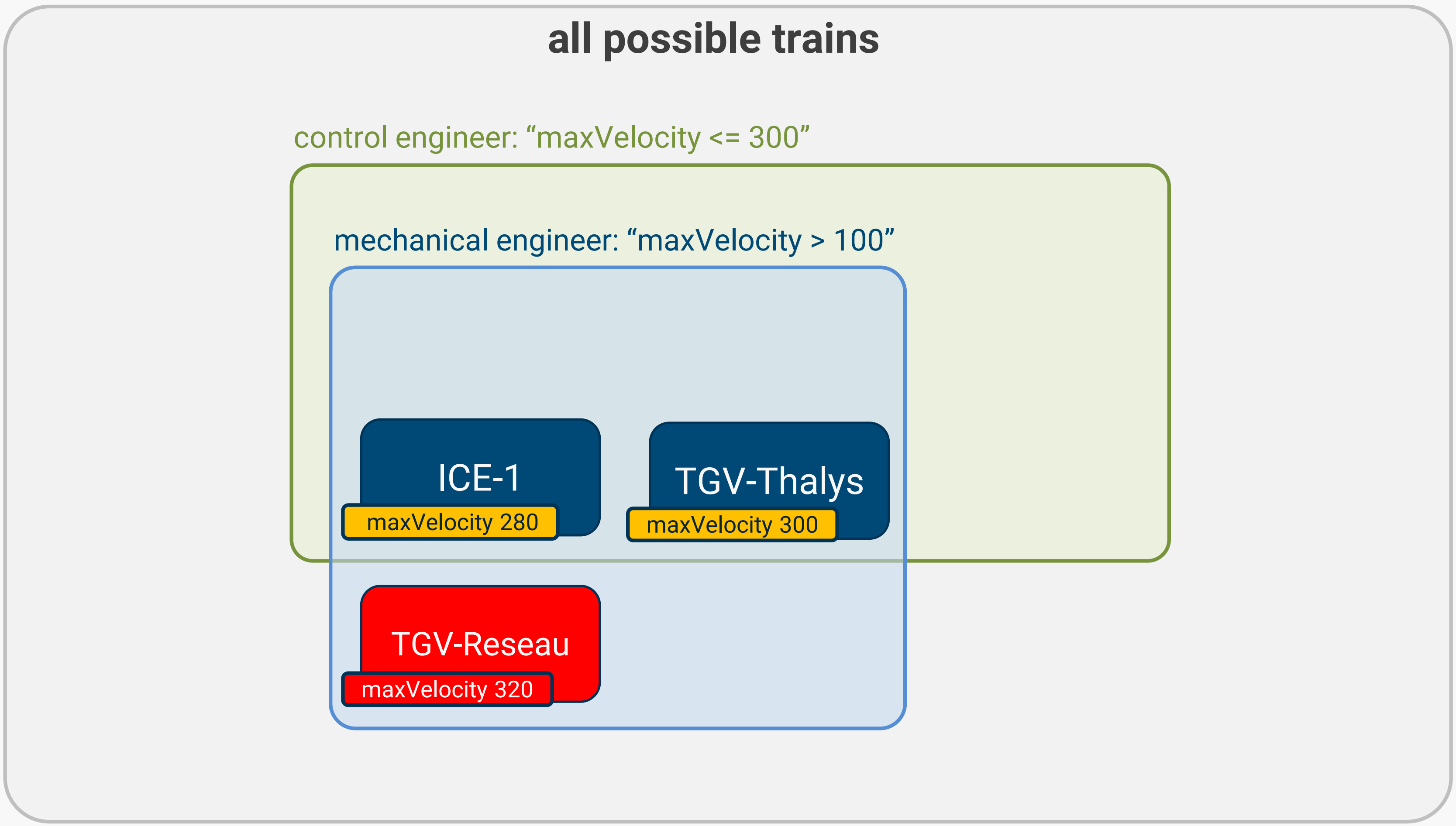
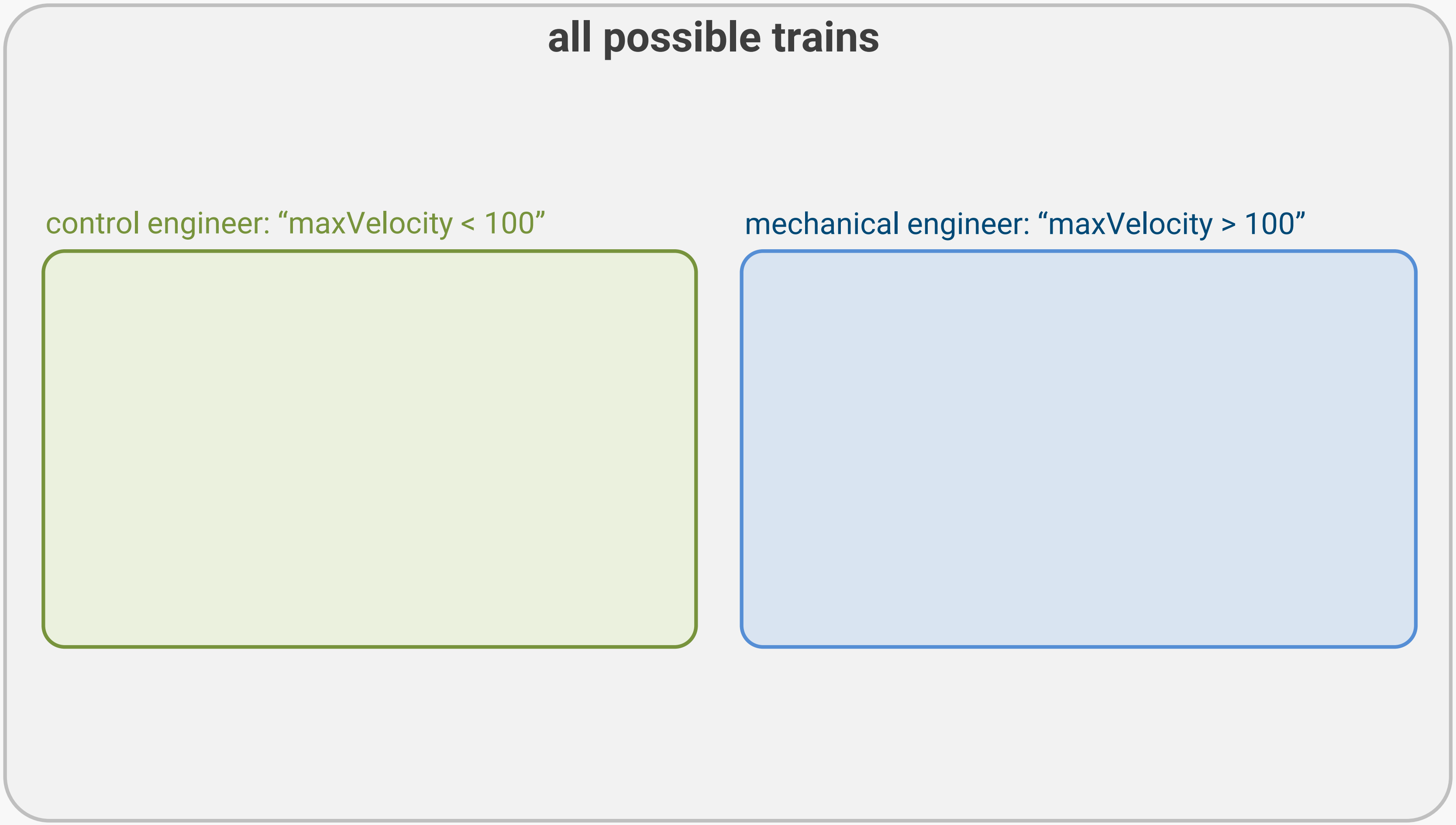
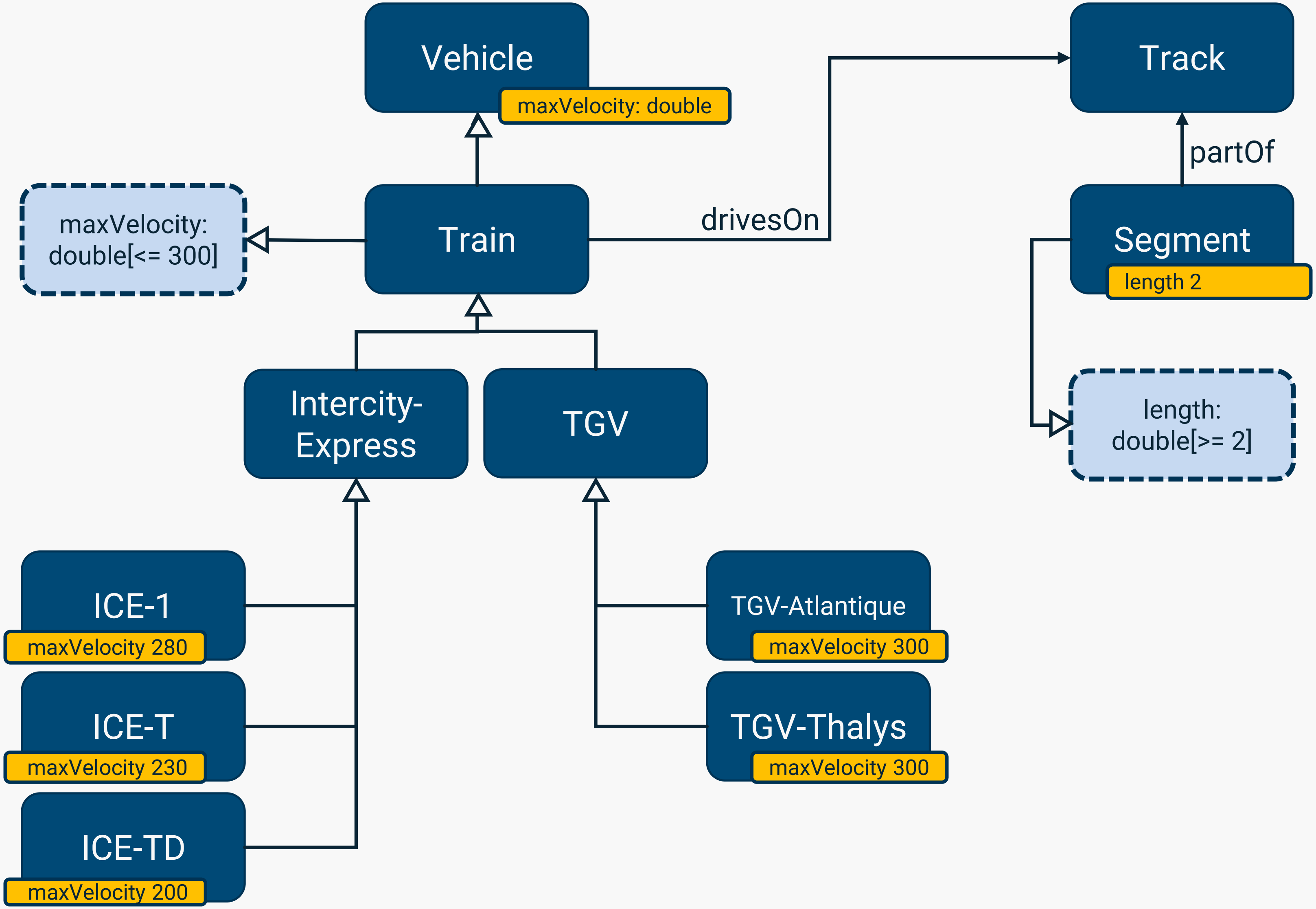


Constraining Entities (2)



Introducing an Inconsistency



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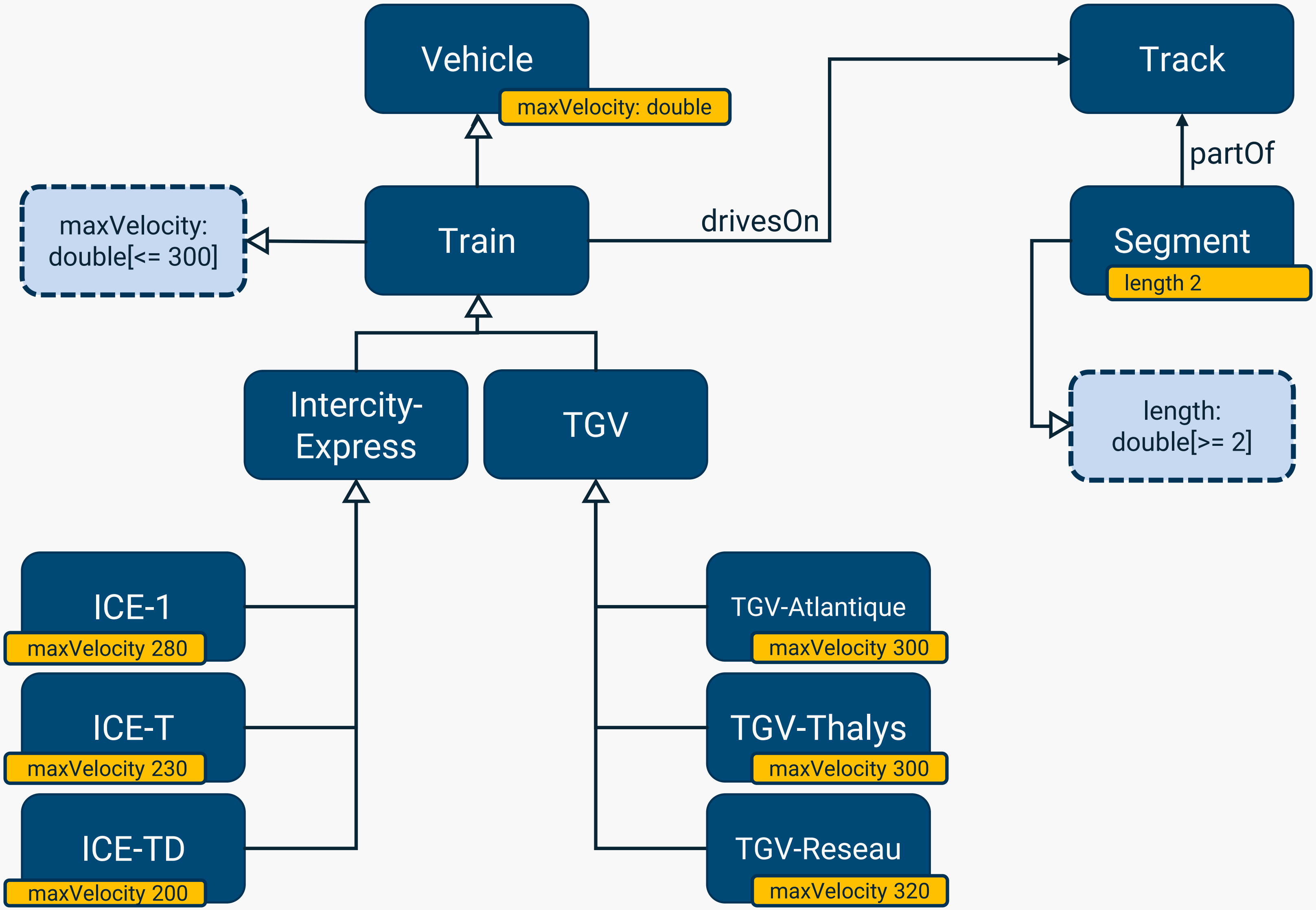

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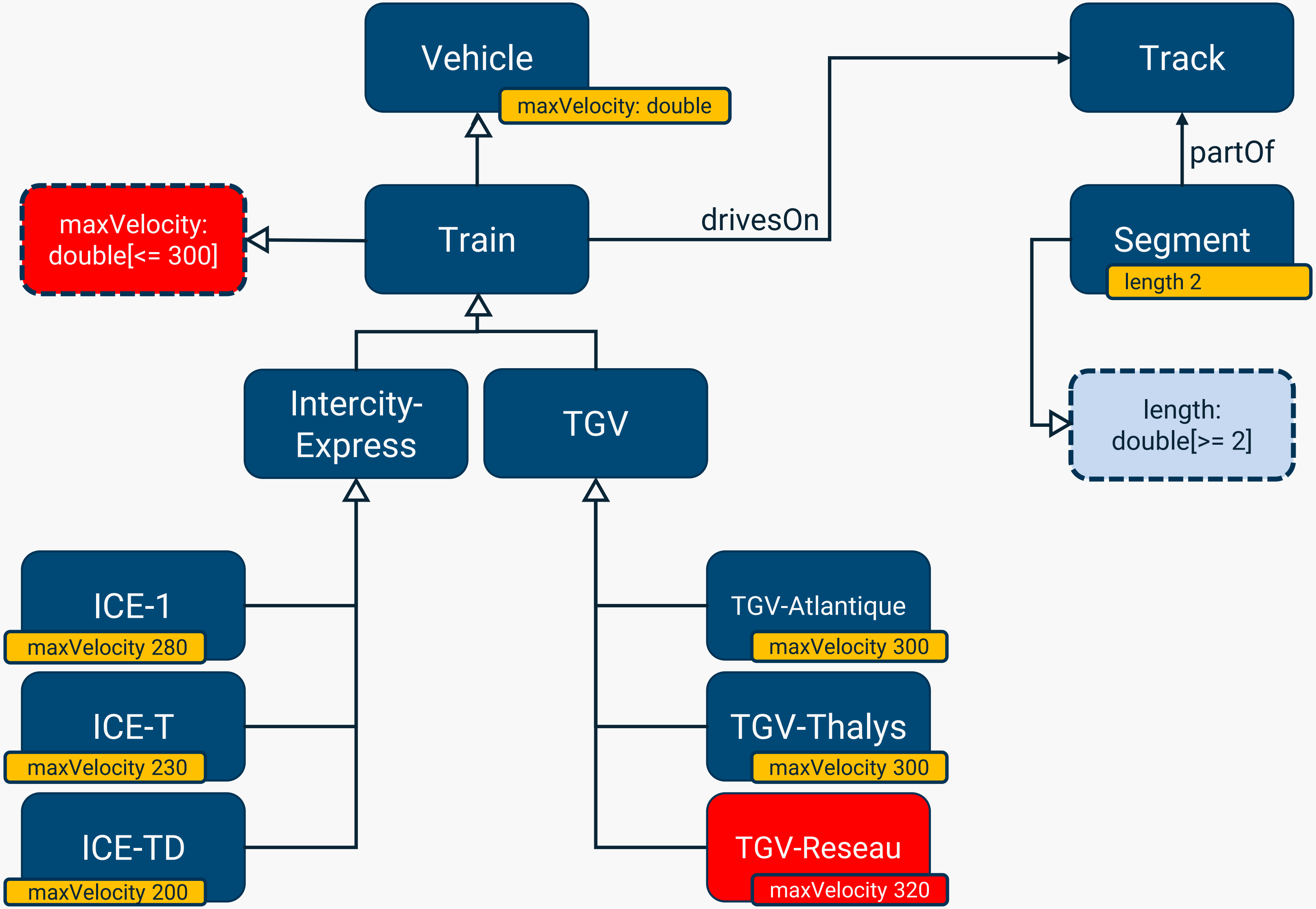

Pitfalls

Some OWL peculiarities

- Open world assumption
- No unique name assumption

Questions

References

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