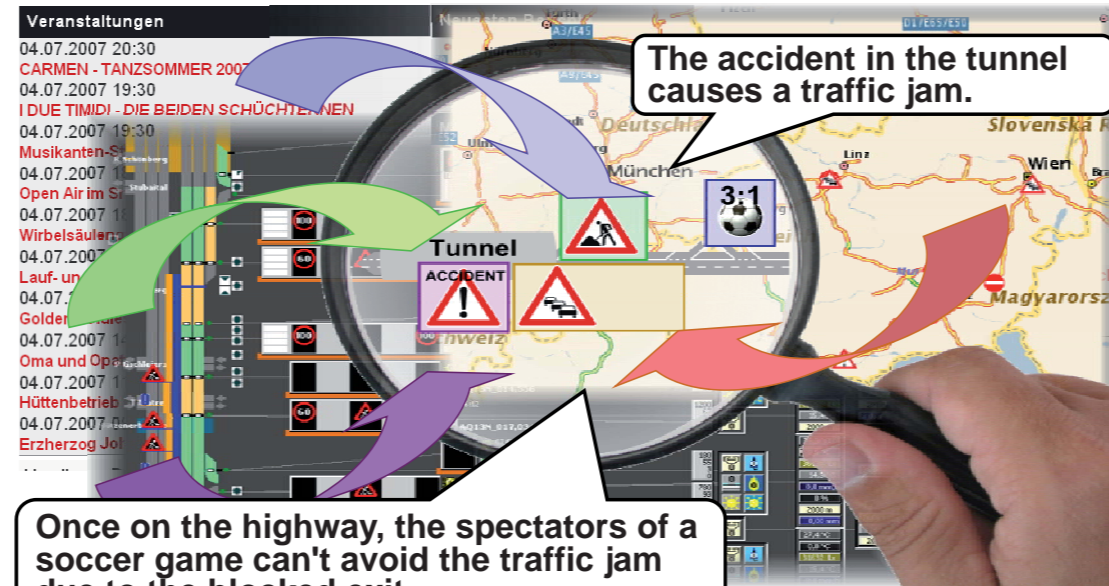# BEAWARE!
An Ontology-Driven Framework for Situation Awareness Applications

Problem

Information Overload in Large-Scale Control Systems

- Large-scale control systems, like in the domain of road traffic management, typically deal with **dynamic environments.**
- They provide a **vast amount of information**, stemming from multiple heterogeneous sources, about a **large number of real-world objects anchored in time and space**.
- Human operators are at risk to **get lost in the induced information overload**.
- This **endangers to timely and correctly identify, resolve and pro-actively prevent critical situations** potentially causing serious impacts in the real world.


The accident in the tunnel causes a traffic jam.

Once on the highway, the spectators of a soccer game can't avoid the traffic jam due to the blocked exit.

Manually identifying a critical situation.

Approach

Situation Awareness

- **A core situation awareness ontology** unifies concepts, such as **Situation**, **Object**, and **Relation** from various domains.
- **Domain-specific ontologies**, like a traffic situation awareness ontology, extend the core situation awareness ontology to provide representations for heterogeneous data sources.
- **Well-known calculi**, such as Region Connection Calculus (RCC), Oriented Point Relations Algebra, Allen's Time Intervals Algebra, and Freksa's Temporal Semi-Intervals, extend the core situation awareness ontology to provide qualitative spatio-temporal relations.
- **Situation types** describing relevant situations are defined on basis of objects and relations.
- The notion of **neighborhood of relations, generalized to neighborhood of situations** enables reasoning about similarity and evolution of situations.
- **Reasoning shortcuts** foster efficient situation assessment by exploiting meta-information about relations.
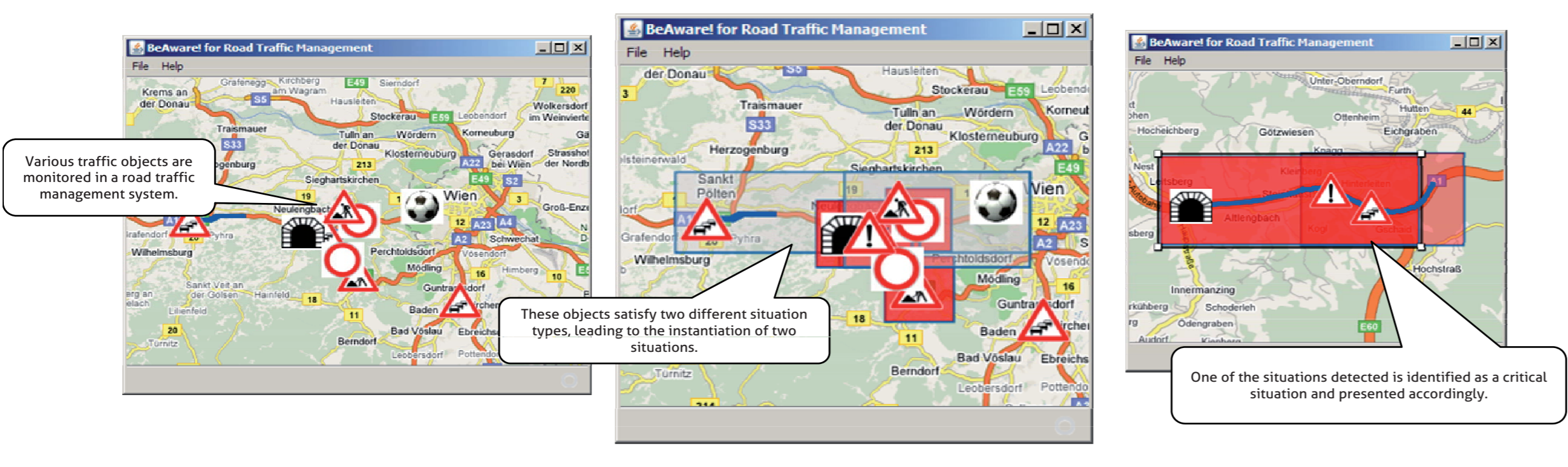

Situation awareness ontologies together with an instantiated situation and its corresponding situation type definition.
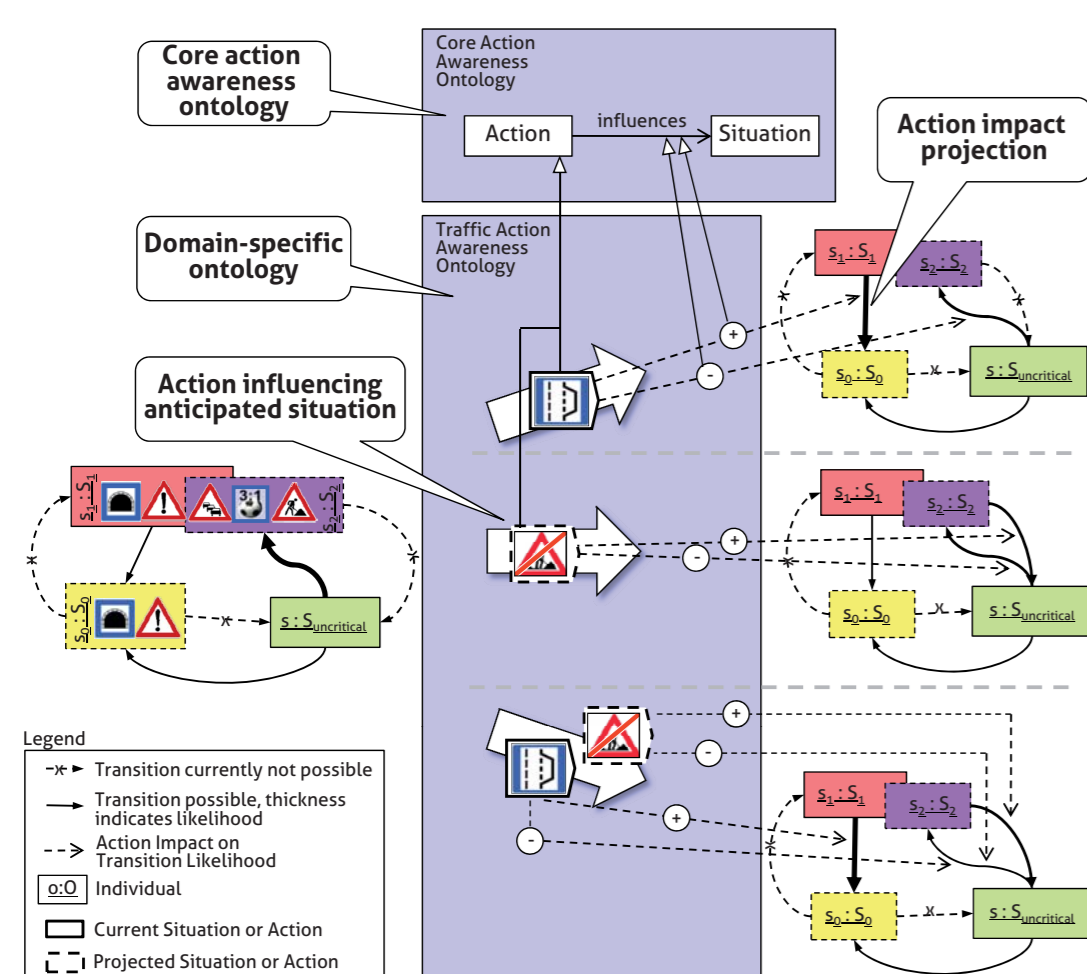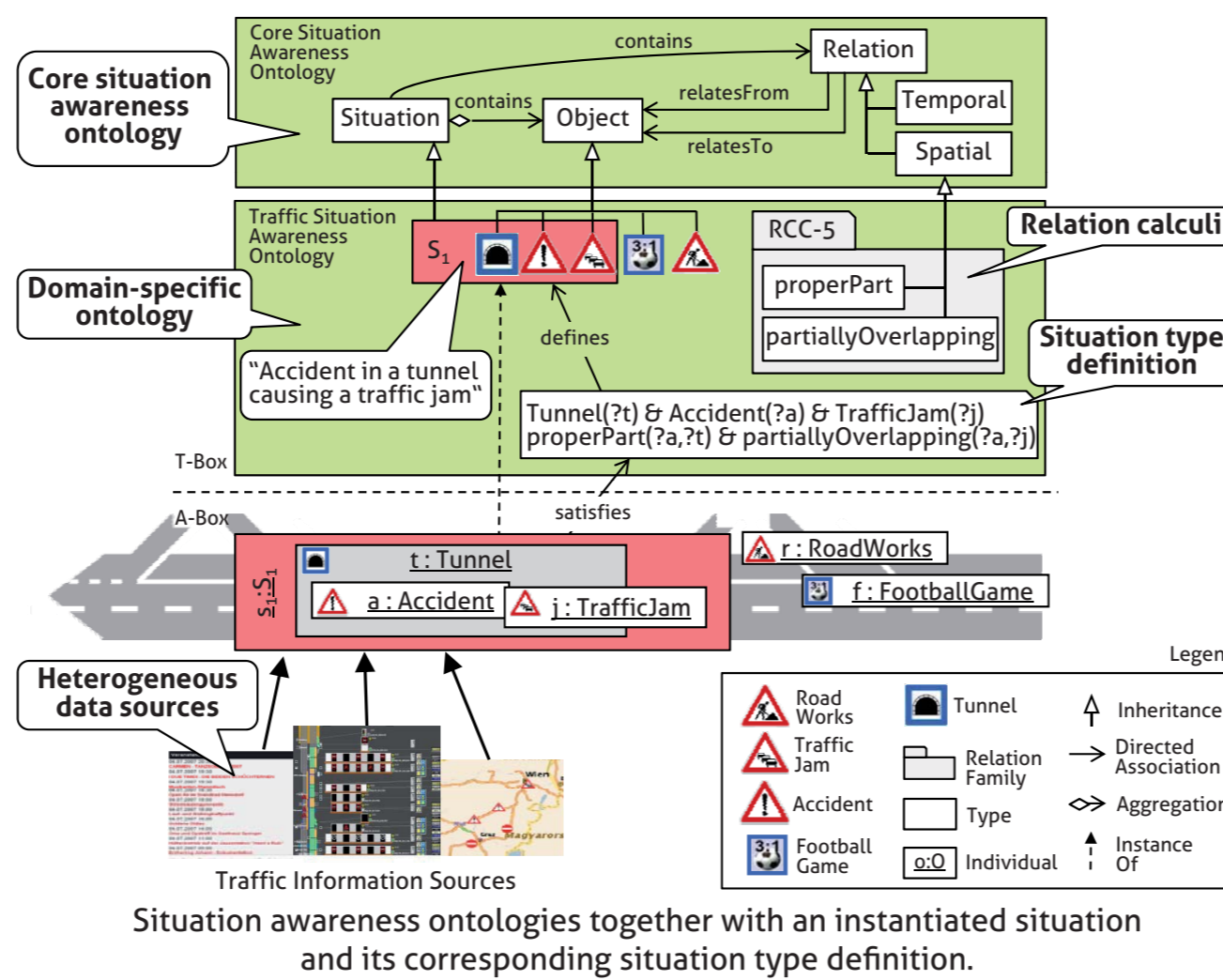
Action Awareness

- **A core action awareness ontology** is integrated with the core situation awareness ontology.
- **Domain-specific ontologies** extend the core action awareness ontology to describe actions of particular domains, and to describe how actions influence likelihoods of transitions between situations.
- **Actions influencing anticipated future situations** are proposed early in time.
- **A priori knowledge of domain experts**, as well as action impact analysis of past actions facilitate projection of action impacts.

Overview of action awareness approaches, actions being taken in an initial scenario (left) lead to three possible future scenarios (right).

Prototype

Various traffic objects are monitored in a road traffic management system.

These objects satisfy two different situation types, leading to the instantiation of two situations.

One of the situations detected is identified as a critical situation and presented accordingly.

Goals

Leverage situation and action awareness in large-scale control systems with **semantic-based methods**, thereby facilitating information **integration** as well as **situation assessment and exchange**.

Situation Awareness

Gain awareness of current and future critical situations:

- **Develop ontologies for situation awareness** as formal and semantically rich knowledge representation of situations.
- **Incorporate qualitative spatio-temporal relations** describing real-world situations with physical objects distributed over time and space.
- **Reason about the similarity and evolution of situations** to anticipate future critical situations.
- **Facilitate efficient and robust situation assessment** with computationally tractable reasoning approaches fulfilling industry-strength robustness requirements.


Key research goals.
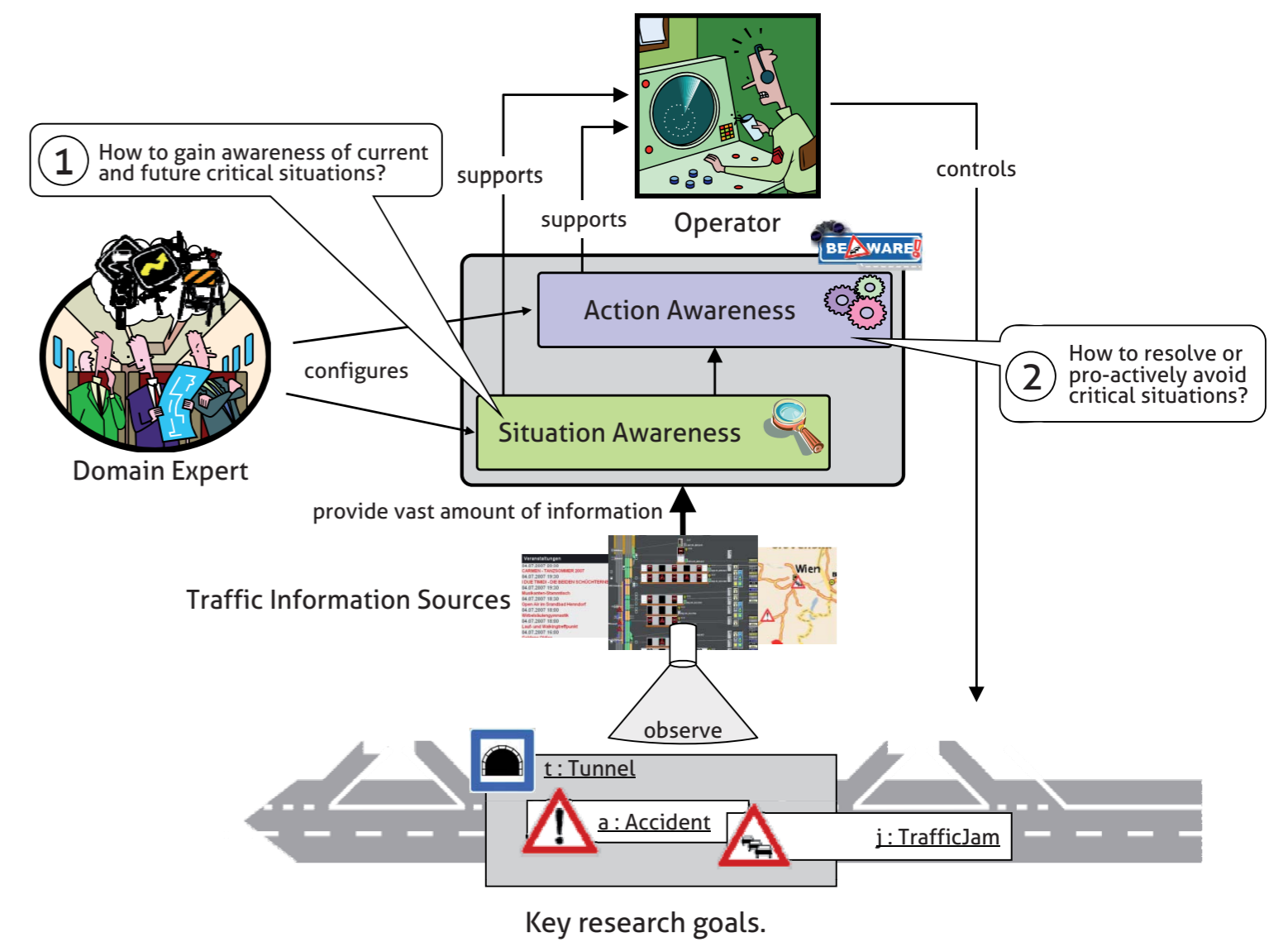
Action Awareness

Propose actions to resolve or pro-actively avoid critical situations:

- **Develop ontologies for action awareness** describing actions integrated with situation awareness ontologies.
- **Elaborate on action assessment** for proposing viable sets of actions resolving current and preventing future critical situations.
- **Project and reason on action impacts** enabling operators to be aware of the effects actions are likely to have.

Evaluation

Evaluation in the Domain of Road Traffic Management

- **Functional and non-functional criteria** focusing on situation awareness and action awareness techniques are developed in accordance with industry partners.
- **Test case design** is performed upon **real-world test data** (critical situations, viable actions), and **information extracted from printed operating procedures**.
- **Tests are based on real-world information** stemming from the commercial road traffic management system GeoDyn 2 provided by Heusch/Boesefeldt.
- **Simulation and offline evaluation** are employed as major evaluation techniques due to potentially negative impacts if testing in real time on real-world road traffic management systems.

Preliminary performance test results.
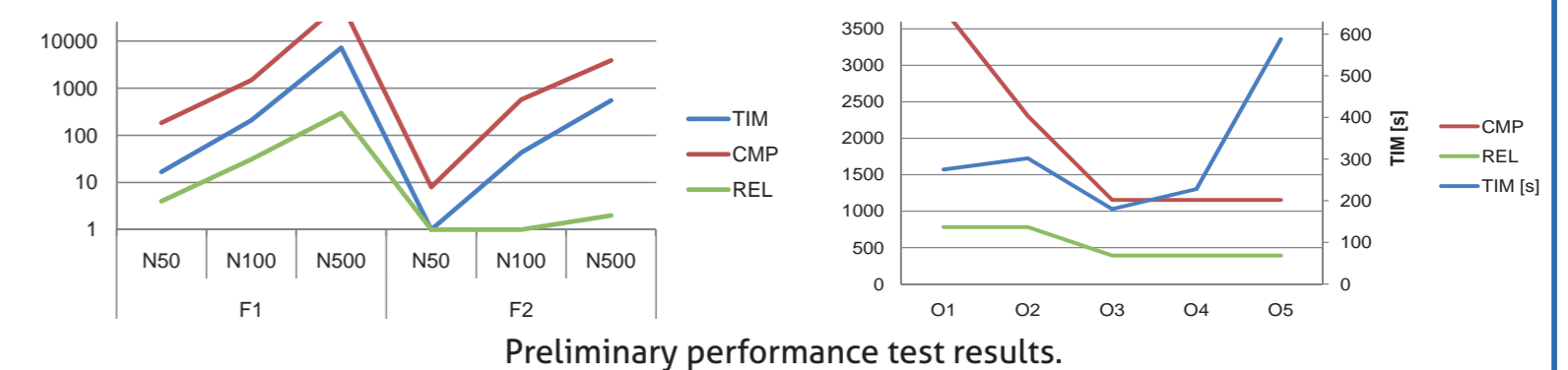
Preliminary Performance Test Results

- **Focused situation types** being satisfied by a small number of object sets only increase performance in comparison to unfocused situation types (cf. F1 vs. F2).
- **Reasoning shortcuts** exploiting characteristics of relations are promising to achieve performance increase (cf. O1 - O4).

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